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MICHIGAN STATE UNIVERSITY

AGRICULTURAL EXPERIMENT STATION

EAST LANSING

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THE QUARTERLY BULLETIN

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MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
R. J. ALDRICH, ASSISTANT DIRECTOR
M. T. ALLEN, EDITOR

SPARTAN RED 8, A NEW TOMATO FOR GREENHOUSE PRODUCTION

By SHIGEMI HONMA, S. H. WITTWER and OTTO HEECKT

Department of Horticulture

Successful production of greenhouse tomatoes depends upon varieties widely adapted to extremes of temperature and sunlight. Michigan-Ohio Hybrid[1], the most popular red tomato variety for greenhouse production in Michigan and adjoining areas, sets fruit poorly under high summer temperatures often experienced with the fall crop. Failure of fruit to set may be confined to the first cluster or may extend to three or four clusters, as it did in the fall of 1959 in commercial greenhouses when serious yield reductions resulted from failure to set on the early clusters.

The ability to set fruit at high temperatures is an important advantage of Spartan Red 8, recently released by the Michigan Agricultural Experiment Station. This variety also has advantages in earliness, less cracking, closer spacing of clusters and uniform ripening. Spartan Red 8 is suitable either as a fall or a spring crop. These desirable traits together with its yielding ability justify its introduction as a greenhouse tomato.

PEDIGREE

Spartan Red 8 is a selection from a cross between a breeding line Nebraska 12[2] and Ohio W-R Globe[3]. During seven generations of inbreeding, plants were selected for earliness, fruit-setting ability under high temperatures, close spacing of fruit clusters, and a deep globe fruit shape with uniform ripening.

[1]Wittwer, S. H. (1953). The Michigan-Ohio Hybrid: A new F_1 tomato for greenhouse production. Mich. Agr. Expt. Sta. Quart. Bul. 36: 191-94.

[2]Supplied by the Nebraska Agricultural Experiment Station, Lincoln, Nebraska.

[3]Alexander, L. J. (1949). Ohio W-R Globe. Ohio Agr. Expt. Sta. Res. Bul. 689.

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DESCRIPTION

Vine

The vine of Spartan Red 8 is indeterminate (Fig. 1). The foliage is sparse compared with Michigan-Ohio Hybrid. The average distance between fruit clusters of Spartan Red 8 is less than for Michigan-Ohio Hybrid. Commercial growers report two to three more clusters of fruit by the height at which plants are topped. The sparse foliage may allow for a closer spacing of plants than for Michigan-Ohio Hybrid.

Fig. 1. Typical fruiting plant of Spartan Red 8 (fall crop, 1960). Note close spacing of fruit clusters.

Disease Resistance

Inoculations of seedlings demonstrated that Spartan Red 8 is not resistant to *Fusarium* wilt[4]. Similarly, Spartan Red 8 is not resistant to leaf mold (*Cladosporium fulvum*), *Verticillium* wilt, or tobacco mosaic virus. A program is currently underway to introduce resistance to these various diseases into a variety of the Spartan Red 8 type.

Fruit

Maturity: The first ripe fruit of Spartan Red 8 has been harvested approximately 5 to 7 days earlier than Michigan-Ohio Hybrid. Yields during the first 2 weeks have generally equalled or exceeded those of this standard variety, (Table 1).

Type: The fruit are medium to large in size, globe-shaped, and average 5-6 ounces (Fig. 1). Spartan Red 8 has the gene for uniform ripening, and the mature fruits ripen to a deep scarlet. The thick outer walls and fleshy interior make the fruit firm and heavy. Because of less cracking than the Michigan-Ohio Hybrid, the fruit can be allowed to ripen to a slightly deeper red before harvesting. The scar on the stem end is less prominent than with other greenhouse varieties.

Performance: A summary of early and total yields for three spring crops and one fall planting at East Lansing, Michigan are presented

[4]Performed by Miriam C. Strong, Department of Botany and Plant Pathology, Michigan State University.

TABLE 1—Comparative early and total fruit yields of Spartan Red 8 and Michigan-Ohio Hybrid

Crop	Variety	Early	Total
		Pounds per plant	
Spring, 1958 (Plastic house)	Michigan-Ohio Hybrid	1.5	10.7
	Spartan Red 8	2.2	12.2
Spring, 1959 (Plastic house)	Michigan-Ohio Hybrid	1.0	9.4
	Spartan Red 8	1.5	8.7
Spring, 1960 (Glass house)	Michigan-Ohio Hybrid	1.0	12.2
	Spartan Red 8	0.9	11.4
Fall, 1960(*a*) (Glass house)	Michigan-Ohio Hybrid	1.4	8.6
	Spartan Red 8	0.7	6.1

(*a*) Topped after six clusters.

in Table 1. The data for the one greenhouse-grown fall crop (1960) do not indicate the usual advantages of the improved fruit setting ability under high temperatures of Spartan Red 8 as compared with the Michigan-Ohio Hybrid. This was because very favorable temperatures prevailed during the late summer which were conducive to a good fruit set on both varieties.

Under good growing conditions, yields of Michigan-Ohio Hybrid may be higher than those of Spartan Red 8. The advantages in yield of Spartan Red 8 are usually observed under adverse growing conditions. High day temperatures (85 to 100° F.) accompanied fruit setting of the first clusters in the two spring crops grown in a plastic greenhouse. This was reflected by higher early yields and total yields which were higher than, or comparable to, Michigan-Ohio Hybrid.

For the past 2 years, Spartan Red 8 has been grown both as a fall and spring crop by a number of commercial growers. A definite advantage in fruit setting under extremely high temperatures was experienced in one commercial greenhouse in the fall of 1959. As a spring crop the fruit is early, attractive in color, smooth and deep. Spartan Red 8 also performs well as an outdoor variety.

CULTURAL SUGGESTIONS

Steam sterilization of greenhouse beds is highly recommended since Spartan Red 8 is not resistant to soil-borne diseases such as *Fusarium* wilt. Soil sterilization is, however, a standard practice among Michigan greenhouse tomato growers and therefore requires no additional operation. Since the foliage of Spartan Red 8 is sparse and somewhat thinner than the Michigan-Ohio Hybrid, the number of plants in a given area of greenhouse space can be increased by 10 to 15 percent. As an example, spacing between plants in the row can be reduced from 15 to 12 inches. The increase in plant population by closer spacing, the earlier fruiting and more compact fruiting with closely spaced fruit clusters all demand high water and generous fertilizer applications during the early fruiting stages to maintain high production. It is especially important that adequate levels of fertility be maintained in greenhouse soils where Spartan Red 8 is to be grown. The irrigation and fertilizer programs outlined elsewhere[5] should be adequate.

[5]Wittwer, S. H. (1960). Practices for increasing the yields of greenhouse tomatoes. Mich. Agr. Expt. Sta. Cir. Bul. 228.

IMPROVING THE TRANSFER OF FARM REAL ESTATE IN THE SAGINAW VALLEY AND THUMB AREA OF MICHIGAN[1]

By ALAN R. BIRD[2]

DEPARTMENT OF AGRICULTURAL ECONOMICS

IN THE SAGINAW VALLEY and Thumb Area of Michigan, land values are high. Are these high land values handicapping men who want to expand their farming operations? If so, what can be done to help these men without penalizing the present landowners? This article is concerned with these questions.

The data were gathered by the writer during a field survey of some 30 farmers in 1959.[3] These farmers were long-term cooperators in the Michigan State University Mail-In Accounting Project. They are thought to be above average in managerial ability and in the extent of owned assets. The sample farms were distributed throughout the survey area. For conciseness, the survey area, the Saginaw Valley and Thumb Area of Michigan, is referred to hereafter as the problem area.

Reported Land Transactions and Recent Land Values in the Problem Area

Observed land sales provide a generally accepted basis for land valuation. Recent sale prices for land in the problem area and some associated rental rates are reported in the following discussion. These rates are high. A factor indicative of and contributing to the high land values is the slow turnover of land, which is reflected in the small number of reported sales.

[1]This report is based on part of a Ph.D. thesis by the writer, "Toward a feasible program to alleviate the United States' agricultural surplus and income problem," department of agricultural economics, Mich. State Univ., East Lansing, 1960, and a cooperative research project with the farm economics research division, U. S. Department of Agriculture.

[2]The writer wishes to thank cooperating farmers and the many others assisting, notably members of the Michigan Cooperative Extension Service and Messrs. G. L. Johnson, W. H. Heneberry, W. B. Sundquist, and C. W. Crickman.

[3]Although this sample of farms is small in a statistical sense, it is of adequate size to delineate some of the more important problems and situations relative to the farm real estate market.

ARTICLE 43-50

Over the whole of the sample, not more than a dozen parcels of land were reported as purchased from outside the family since 1930. Prices reported for such purchases by farmers included in the sample and their neighbors within the last 5 years included 80 acres (untiled) for $36,000, 80 acres (chiefly untiled) for $40,000, 80 acres (partly tiled) for $65,000, 60 acres for $46,000 (untiled land urgently needed for expansion by a neighbor), and an undisclosed area for $700 an acre.

Some land close to the cities of Bay City and Saginaw is alleged to be worth $1,000 an acre. Recently reported cash rentals for partly tiled land on the better soils range from $900 for 50 acres to $2,600 for 80 acres. Some untiled land in areas of Bay County in which drainage outlets are not available is reported to rent at $10 an acre. Some similarly poor land at the tip of Huron County (but without access to the coast) is reported to sell for $125 to $150 an acre.

The only land sold by any of the sample members in the last 30 years has been eight separate instances of very small lots (up to 10 acres), which were needed by public utilities or sold as urban building lots. Fifteen farmers volunteered the observation that land throughout the district generally remained "in the family."

Increases in land values can result from (1) increases in the demand for land when the supply is constant, (2) decreases in the supply of land when the demand is constant or, more likely, (3) from some combination of increases in the demand for land *and* decreases in the supply. An analysis of the conditions of demand and then the conditions of supply for farming land in the problem area follows. If the small farmer is to be helped to expand in the face of high land values, some ways of increasing the supply of farming land seem to be needed. The paper ends with suggestions as to ways of doing so.

The Demand for Farming Land in the Problem Area

A commercial farmer buys or rents more land because he believes that he can increase his income by farming more land. About 75 percent of the farms in Type-of-Farming Area 8 (which includes the problem area) contain less than 140 acres.[4] Brooke[5] recently found that small farms in the problem area had "too much machinery and

[4]Hill, E. B. and R. G. Mawby (1954). Types of farming in Michigan, Mich. Agr. Expt. Sta. Spec. Bul. 206, p. 9.

[5]Brooke, M. David (1959). Returns to inputs and investments on cash crop farms in the Thumb and Saginaw Valley area of Michigan, 1957, Mich. Agr. Expt. Sta. Quart. Bul. 42: 250.

labor," and Dvorak[6] has shown that a 160-acre farm in the area could profitably expand to 320 acres.

The following field observations by the writer and the reported high price of land confirm the expected heavy demand for farming land. They point also to some likely dissatisfactions with present conditions of land rental which further increase the demand for land for purchase.

All except three of the sample members said they would buy or rent more land if they could get it. The exceptions, moreover, were exceptions by virtue of some personal condition, *e.g.*, approaching retirement. A preference for buying over renting was indicated by all except one of these men. (He thought that renting would be cheaper). Buying was thought to be necessary to give security of tenure and to enable necessary improvements (notably drainage) to be made.

Some further corroboration of their expressed need for more land is given by the evidence of how intensively sample members are using the land they own. Only two farmers said they owned significantly large areas of land that still needed new tiling.[7] Both of them were concerned with not "going into debt" and said they planned to complete tiling as spare cash became available from good crop years. Most of the rest mentioned the need for closer spacing of tiles. They indicated that their entire farms had been drained, but that they were putting in extra drains on some fields.

The largest area reported to need this "in-between" tiling was an 80-acre tract purchased within the last 5 years. Otherwise two 40-acre fields and one 20 acres were reported to need drainage; but these fields could not be drained until further land was acquired to enable the provision of outlets. Accordingly, the considerable extent to which drainage has been undertaken by sample members on their own land is consistent with other evidence of the urgency of their demand for extra land.

Further evidence of the ability of some sample farmers to work more land than they now have consisted of three notable instances

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[6]Dvorak, F. E. (1959). Programming the organization and capital use for a cash crop farm in the Saginaw Valley and Thumb area of Michigan. Thesis for degree of M.S., Mich. State Univ., East Lansing, p. vi. (Unpublished).

[7]The likely profitability of drainage is illustrated by the following: C. R. Hoglund budgeted costs and benefits from tiling on a "typical" 150-acre level farm in the problem area on Brookston loam and clay loam soil. He concluded that tiling would pay for itself in 6 to 8 years. Such a practice could be expected to be worthwhile, then, even if a fall in product prices resulted in an extension of this repayment period. There is, of course, a subsidy available for tiling, too. See Hoglund, C. R. (1955). "Managerial decisions in organizing and operating a farm," Ag. Econ. No. 625, Dept. Agr. Econ., Mich. State Univ., East Lansing, pp. 5-6; and "Investments in drainage pay off," *Sugar Beet Jour.*, Farmers and Manufacturers Beet Sugar Association, Saginaw, Mich., June 1955, pp. 1 and 4.

(and several lesser ones) of custom work done on other farms and of standing crops purchased from neighbors and harvested and marketed with the farmer's normal labor force and equipment. This evidence is consistent with Brooke's and Dvorak's findings reported above.

The general ability on the part of farmers to use existing field equipment to work a larger area of land (without need for any other significant adjustment) is further confirmed by answers to the question, "How would you use more land, if you could get it?" All the respondents stated that they would use extra land to grow more cash crops or "fit it into the rotation." None of the farmers interviewed cited the need for more land to grow forage crops. In addition, five of the farmers volunteered the information that they were already cash cropping all their present land, except what was needed for pasture, and buying hay and grain for their cows.

Some government programs were alleged to encourage the buying of land over renting it.[8] Several farmers alleged that there was less land available for renting now than in the past because of the "soil bank." Instances were cited of up to 120 acres being put in the soil bank by individual owners. The presence of the soil bank was alleged to be adding to the already considerable insecurity of tenure which almost all farmers remarked upon. Two exceptions were operators with cash rental contracts extending over a period of 2 years or more.

Only two of the sample farmers indicated such an aversion to borrowing (by their hesitancy to complete drainage on property already owned) that they could be expected to forego any opportunities to buy land at a "reasonable price." Allowing for all exceptions, then, about 70 percent of the sample farmers were anxious to buy more land and would probably bid on land coming up for sale. If, as suspected, this sample contains "above average" farmers, this figure of 70 percent would be higher than for the district as a whole.

Because of the availability on a continual basis of larger capacity field machinery, heavy demand for farming land is likely to increase still further. A specific example of the potential for this increase is provided by the sugar industry. (Sugar beets are one of the three most important cash crops in the area.) An industry source reported that in 1959, almost the entire Michigan sugar beet crop was harvested with single-row machines. Machinery manufacturers have now mar-

[8]However, all framers who volunteered an opinion considered that the soil bank had an overall negligible effect on production plans on their present land. Restrictions imposed by acreage allotments were said to prevent the "best use" of machinery and to encourage farmers to seek land to add to their farms.

keted 2-, 3-, and 4-row harvesters, though not yet in Michigan. A 1959 price list[9] shows that these larger capacity machines have been priced low enough, relative to the single-row harvester, to encourage farmers to buy them. (A necessary prerequisite to expanding sugar beet acreage in addition to more land is, of course, the availability of a larger acreage quota to the grower.) Even without the inducement of such general obsolescence in existing field machinery, however, farmers will have inducement enough in likely increased income to adopt larger capacity machinery, if only they can control a large enough acreage to work this larger equipment.

Overall, then, the demand for farming land in the problem area is high and likely to increase. This heavy and increasing demand encourages still further increases in land values.

Despite these high land values, farmers who wish to expand their operations show a strong preference for buying land rather than renting it. Almost without exception, the men who were renting land indicated that they rented it so they could have first option for later purchase. Several sample members, who had previously bought land after renting it in this way, had been forced to rent for 10 or more years. Moreover, they complained that the land they had rented was in need of drainage and, prior to purchase, could be used only for pasture and grain crops, which were less susceptible to poor drainage conditions than the higher return cash crops such as beans and sugar beets.

The Supply of Land in the Problem Area

Given the above evidence of a strong demand for land for cash cropping in the problem area, any measures that would contribute to an increase in the supply of land for this purpose could be expected to encourage young men to expand their farming operations by working more land. This encouragement would take the form of lower land values or of making land available for rent on terms more satisfactory to the small farmer.

In order to find ways of increasing the supply of land, it is first necessary to identify the marginal suppliers of land for either renting or buying. The potential marginal suppliers of land are now cited. Supporting evidence suggests that these landowners currently have little inducement to sell their land.

[9]For example, for comparable models of one brand, a single-row machine was listed at $3,656 and a 2-row machine at $4,027. For another brand, comparable 2- and 3-row machines were listed at $2,696 and $3,357, respectively.

All the sample members (except those located at the tip of Huron County away from the coast) indicated that land was hard to get and tended to stay within the one family. The marginal suppliers of land are likely, therefore, to be drawn from owners who have no heirs wishing to farm their land. At least three instances of sample farm owners in this position are known. Several farmers (in different parts of the problem area) testified to the presence of widows in the immediate neighborhood who were renting out all their land outside the family or putting it in the soil bank. Data[10] based on a recent random sample of Michigan farms suggests that the prevalence of farm owners without heirs interested in farming is much greater than is indicated in the present writer's purposive sample.

In the best parts of the problem area, the minimum current cash rental reported was about $20 an acre and the minimum estimated sale price about $500 an acre. The maximum reported cash rental was about $32.50 an acre and the maximum estimated sale price about $800 an acre. If there is a perfect positive correlation between cash rental and sale value (no doubt a practical tendency but unlikely to be a fully realized situation), the gross return on present value from cash renting is likely to vary around 4 percent per annum.

For Type-of-Farming Area 8 in 1958, William Heneberry[11] reports that the average real estate taxes payable by a landlord were only about $1.77 an acre, and typically the landlord's other expenses are not high. Hence, the above estimates of likely gross returns from renting of about 4 percent on current value may approximate net returns.

In general, farmers are reported[12] to be expecting further increases in land values. Since landowners in the problem area already appear to be receiving a satisfactory return from renting out their land and may expect land values to increase further, it is not surprising that many of them continue to cash rent on an annual basis. The uncertainty of these widows and older farmers concerning other sources of investment that yield comparable returns with no greater risk of capital depreciation is likely to be great enough to cause them to retain ownership of their farms.

Under a cash rental agreement that includes a hidden advance

[10]McKee, Dean, personal communication based on data from regional dairy adjustments study, made in cooperation with U. S. Department of Agriculture.

[11]Personal communication based on data from the farm economics research division, U. S. D. A., derived by a purposive sample collected by county treasurers.

[12]"The farm real estate market," July-Nov. 1959, ARS 43-118 (CD-54), U. S. Department of Agriculture, agricultural research service, Wash., D. C., Feb. 1960, p. 9.

purchase installment in the annual rental payment to foster and maintain goodwill, what incentive does a widow, even one without heirs, have to sell her land instead of renting it out?

For a given farm, one might assume that most of the land could be sold and still leave the home lot intact. This assumption eliminates the possibility that a widow or older couple considers sale of the farm identical with sale of her home and the severing of connections with the local community. If a widow were to sell this land (exclusive of the home lot), she would very likely find it advantageous to make the sale by land contract, or in any case, to arrange payment over a number of years to avoid heavy incidence of the capital gains tax.

Even if a widow considers the possibility of reducing the tax liability from capital gains when she sells her property, it is possible that she has underestimated the current value of her property enough that her income from renting is about the same as the income she could expect from sale of the property and reinvestment of the proceeds.

Possible Ways of Increasing the Supply of Land

It is doubtful whether ways can be worked out to encourage much increased sale of farm land in the near future. But without increased land sales, much could be done to eliminate the most severe handicap facing the small commercial farmer who wishes to expand his operation. The primary method by which small farmers could be helped to farm more land efficiently seems to be through the introduction of improved tenure agreements.

The handicap (as it appears in the sample data) is the limitation on production on rented land because the lack of security of tenure prevents the carrying out of drainage improvements. The most positive remedy seems to be a revision of tenure arrangements to enable prospective tenants to rent for a sufficiently long time and/or with sufficient guarantee of compensation for productive improvements to encourage them to make such improvements as drainage.

Periodic revision of rentals (say, every 5 years) would tend to safeguard the landowners' interests by enabling rentals to be adjusted in conformity with changes in land values. Moreover, the tenant who is a prospective buyer would then be better able to buy the land when the sale is made. He would be able to improve the productive capacity of this land in relatively small installments prior to purchase.

Drainage (currently costing about $100 to $125 per acre) is an important example of such improvements. Although such long-range tenure arrangements have no widespread precedent in the United States, they have been used extensively and successfully elsewhere.

Exemption of widows (or anyone else) from payment of the capital gains tax when they sell farms and reinvest the proceeds in nonfarm securities might be a further way of encouraging widows and other nonoperating landowners to sell their farms. Alternatively, land sellers might be exempted from capital gains tax if the buyer uses the additional land to provide a minimum optimal sized farm unit. (Of course, careful drafting of the legislation would be necessary to prevent abuse.) Provision of further information on alternative investment opportunities by reputable authorities would also be helpful but perhaps difficult to implement.

Any special easing of credit terms for land purchase is not likely to help the small farmer buy more land without bidding up the price of land still further. In the first instance, easier credit terms would only increase the demand for farming land. The same small farmers (and a few more) would then be bidding against each other to force an increase in land values. It is possible that land values could then be raised high enough that it would no longer be profitable for a farmer to buy land at all.

SUMMARY

Land values as high as $700 to $800 per acre have recently been reported for farms on the best lands of the Saginaw Valley and Thumb Area of Michigan. Because many farmers need to enlarge their farms to increase their incomes, these high land values are likely to persist.

Moreover, since sales of farming land are relatively infrequent, the small farmer who wishes to expand is often forced to rent poorly drained land for long periods, in the hope that he will have first option on later purchase. Under these conditions, both the landowner and the tenant could benefit from the development of improved tenure agreements. The most needed improvements are the provision of longer-term security of tenure and means of compensation to the tenant to enable him to carry out drainage improvements. The landowner could be protected by the provision for periodic revision of rental rates.

Landowners most likely to rent out or sell land are widows and

older farmers without heirs wishing to farm. Special measures to encourage the sale of this land might help small farmers to enlarge their farms into more economically sized units. An example of such a measure might be the exemption of these widows and older farmers from capital gains tax from the sale of farm land, provided the buyer uses the additional land to provide a minimum optimal sized farm unit.

USING A GLASS ELECTRODE FOR ESTIMATING EXCHANGEABLE POTASSIUM IN SOILS

By M. M. MORTLAND

Department of Soil Science

Soil acidity has been estimated for many years with a glass electrode reversible to the activity of H^+ ions in combination with a calomel reference electrode. Such measurements are frequently made the basis of liming recommendations in the soil testing laboratory. Recently, a glass electrode selective for Na^+ ions has been placed on the market by the Beckman Instruments Inc. Another electrode sensitive to Na^+, Li^+, H^+, and K^+ ions is also available from the same company. Bower[1] has used these electrodes for estimating the quality of irrigation water with a great deal of success.

The 78137V cationic-sensitive glass electrode made by Beckman Instruments, Inc., is sensitive to the activity of potassium. This being so, it is possible it may be applied to the estimate of potassium activity in soils just as ordinary glass electrodes are employed to determine the hydrogen ion activity.

Several problems are connected with the use of this electrode for this purpose. The electrode is reversible to H^+, Na^+, and Li^+ ions as well as K^+ ions. Because of this, any amount of these ions in the soil to be analyzed will be reflected in the resulting EMF observed and consequently will give high readings compared with the actual amount of potassium present. It is likely that the concentration of Li^+ and Na^+ ions in acid soils will be relatively small and may contribute very little to the observed voltage. There will be exceptions, of course, since a few soils are observed to have appreciable exchangeable sodium. The effects of H^+ ions can be reduced so that their influence is small by making measurements in alkaline systems.

[1]Bower, C. A. (1959). Determination of solium in saline solutions with a glass electrode. Soil Sci. Soc. Amer. Proc. 23: 29-31.

ARTICLE 43-51

EXPERIMENTAL METHODS

Thirty Michigan soil samples, selected to give a wide range in soil test for potassium, were utilized in this study. These were the same samples which Cummings[2] studied in his investigation of the relationship of potassium release to the clay mineral composition of the soils. The regular soil test data from these samples were obtained from the Michigan State soil testing laboratory. The method utilizes 0.13 N HCl as an extraction solution with shaking for one minute before filtration. The exchangeable potassium was determined by extracting 10 g. of soil with 100 ml. of neutral normal NH_4 acetate. These samples were shaken overnight then filtered and analyzed on a Coleman flame-photometer. The potassium exchangeable to magnesium was determined by shaking 10 g. soil samples in 100 ml. of 1N magnesium acetate overnight, then the supernatant liquid was analyzed for potassium on the Coleman flame photometer.

Estimations of potassium contents of these very same soil-magnesium acetate systems were also made with the cationic-sensitive electrode with a calomel reference electrode. A series of standard solutions of KCl in 1 N magnesium acetate was made up ranging from 10^{-5} N to 10^{-1} N with respect to the concentration of KCl. Data in Fig. 1 show the relationship between the EMF and concentration of potassium as measured with the Zeromatic Beckman pH meter. The slope of the curve is 55.3 millivolts per ten-fold change in concentration, a figure not too different from the theoretical 59 millivolts of the Nernst equation: $E = E_o + 59 \log (K^+)$ where E is the measured potential, E_o a combination of the reference cell potential and the standard state potential and (K^+) is the activity of potassium.

For the actual construction of a working curve which related EMF to potassium concentration, a 700 ohm resistance was placed in the thermo compensator plugs in the back of the instrument. This gave a ten-fold increase in sensitivity of the instrument so that 10 units of change on the dial reflected 10 millivolts change in the system.[3] The use of 1 N magnesium acetate as an extracting solution had three functions: (1) it supplied a uniformly high pH thus keeping interference by H^+ ions at a minimum, (2) the high concentration of Mg^{++} ions replaced almost all the exchangeable potassium

[2]Cummings, S. L. (1959). Relationships of potassium fixation and release to the clay mineral composition of some Michigan soils. Thesis for degree of M.S., Mich. State Univ., East Lansing.

[3]Suggested by C. A. Bower, U. S. Salinity Laboratory, Riverside, California.

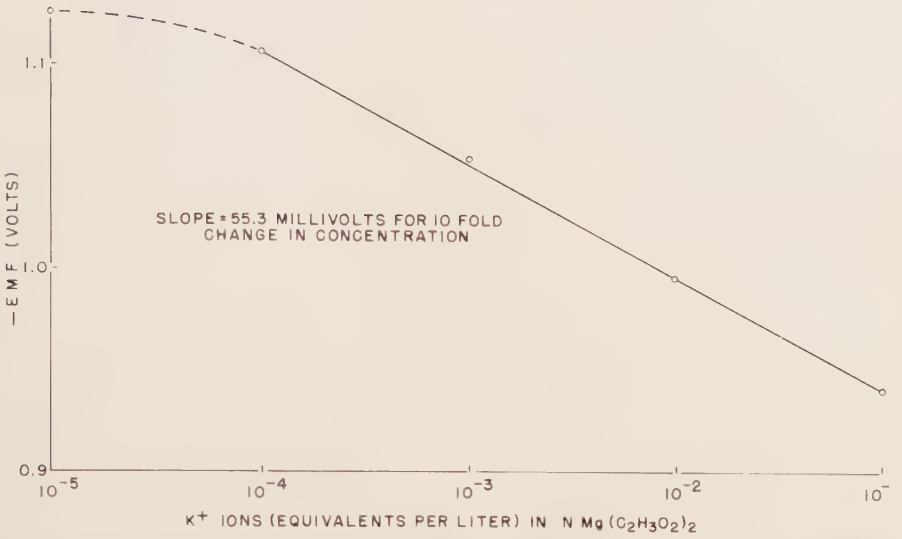

Fig. 1. Relationship between response of the Beckman cationic electrode (negative E.M.F.) and potassium concentration in N magnesium acetate.

into the solution where it could be measured with the electrode, (3) the high salt concentration resulted in a rather uniform ionic strength, regardless of the amounts of exchangeable ions released into the solution, so that the activity coefficient of potassium was maintained at a uniform level. This allowed direct conversion from the activity measurement with the glass electrode into a figure for the concentration of potassium present by comparing values obtained in soil-magnesium acetate systems with values obtained in KCl-magnesium acetate systems as seen in Fig. 1.

Some deviation from the linear portion of the curve is shown at the most dilute concentration 10^{-5} equivalents of K^+ ions per liter. Most figures obtained on soils, however, were between 10^{-4} and 10^{-3} equivalents per liter. The few that were more dilute than 10^{-4} were quite close to that figure so they were still pretty much on the linear portion of the curve. The actual measurements merely involved placing the electrodes directly in the soil-magnesium acetate system and observing the resulting EMF. No filtration or other separation of the soil from the extracting solution was necessary.

DISCUSSION

Fig. 1 establishes the response of the cationic-sensitive electrode to potassium concentration in a high salt medium (1 N magnesium

acetate). Fig. 2 shows the relationship between exchangeable potassium of 30 Michigan mineral soil samples, as determined with the electrode and that determined with the flame photometer on the same magnesium acetate solutions.

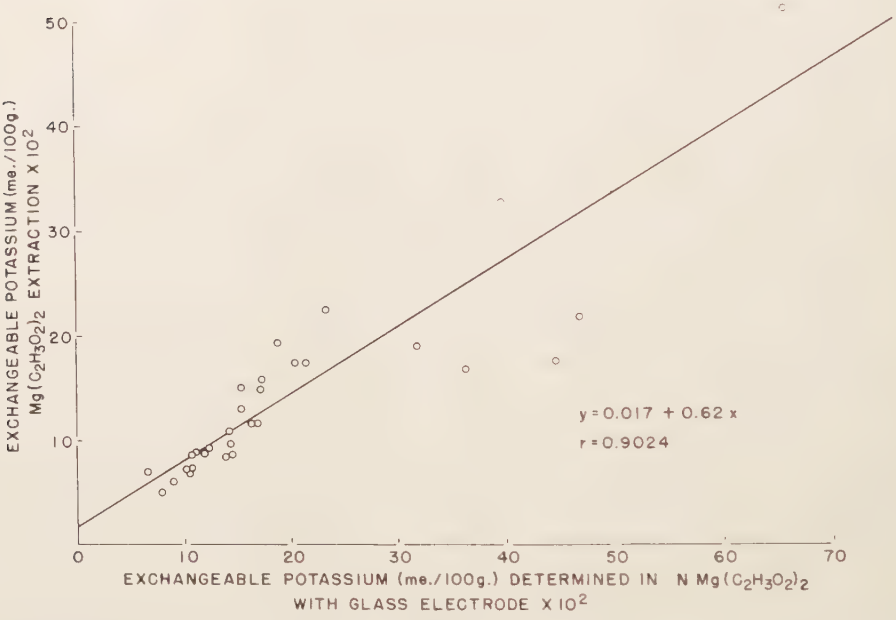

Fig. 2. Relationship between soil exchangeable potassium determined on the flame photometer and with the Beckman cationic electrode.

A relatively good correlation is shown particularly at the lower levels of exchangeable potassium with an overall correlation coefficient of 0.9024. The primary source of error for the electrode measurements is that they reflect not only potassium activity but also sodium activity. Evidently, however, the amounts of sodium present in the soils sudied were not so large or so variable as to prevent a good estimate of the levels of exchangeable potassium with the electrode. Some of the samples which deviated the most were checked as to their exchangeable sodium levels. The deviation of a portion of these samples could be explained on the basis of their sodium contents, while others could not.

Occasionally, the ammonium ion (NH_4^+) is present in appreciable quantities on the exchange complex of soils. While this ion was not included in the list which were supposed to affect the cationic-

sensitive electrode, the author obtained EMF values at various concentrations of NH_4^+ ions in 1 N magnesium acetate. The results are shown in Fig. 3 where it is obvious that the electrode is sensitive to the activity of NH_4^+ ions, the slope of 57.5 millivolts per ten-fold change in concentration being near the theoretical for obedience to the Nernst equation.

In view of this finding, it is apparent that any appreciable concentration of NH_4^+ ions in the system will result in error in the estimation of the level of exchangeable potassium in soils with the cationic-sensitive electrode. Notwithstanding, the high correlation observed in Fig. 2 suggests that most mineral soils found in Michigan do not have enough Na^+ or NH_4^+ ions on their exchange complex to give a large error in the estimation of exchangeable potassium or they contain relatively uniform amounts of these ions, either singly or in combination, so that a good correlation for exchangeable potassium results. Organic soils would likely have enough exchangeable NH_4^+ ions to give appreciable error. Also some acid mineral soils, as well as neutral to alkaline ones, have enough sodium present to affect the results.

The relationship between exchangeable potassium determined on 30 soils with the electrode in 1 N magnesium acetate and exchangeable potassium determined by extraction with 1 N ammonium acetate and analyzed on the flame photometer is shown in Fig. 4. The

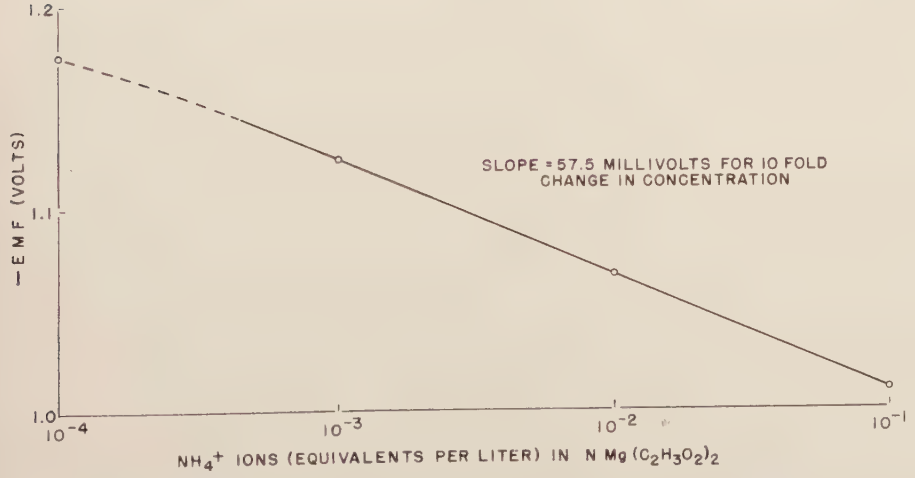

Fig. 3. Relationship between response of the Beckman cationic electrode (negative E.M.F.) and potassium concentration in N magnesium acetate.

correlation coefficient of 0.8254 suggests a relatively good relationship. Data in Fig. 5 show the relationship between the exchangeable potassium determined with the electrode and available potassium as estimated by the analysis in the soil testing laboratory (0.13 N HCl-extraction for one minute). Here a very poor correlation coefficient of 0.384 was obtained, suggesting that this soil test is not a good indicator of the level of exchangeable potassium. The correlation coefficient between the soil test data and exchangeable potassium determined by ammonium acetate extraction was 0.277, again indicating a relatively poor relationship between the soil test and exchangeable potassium levels.

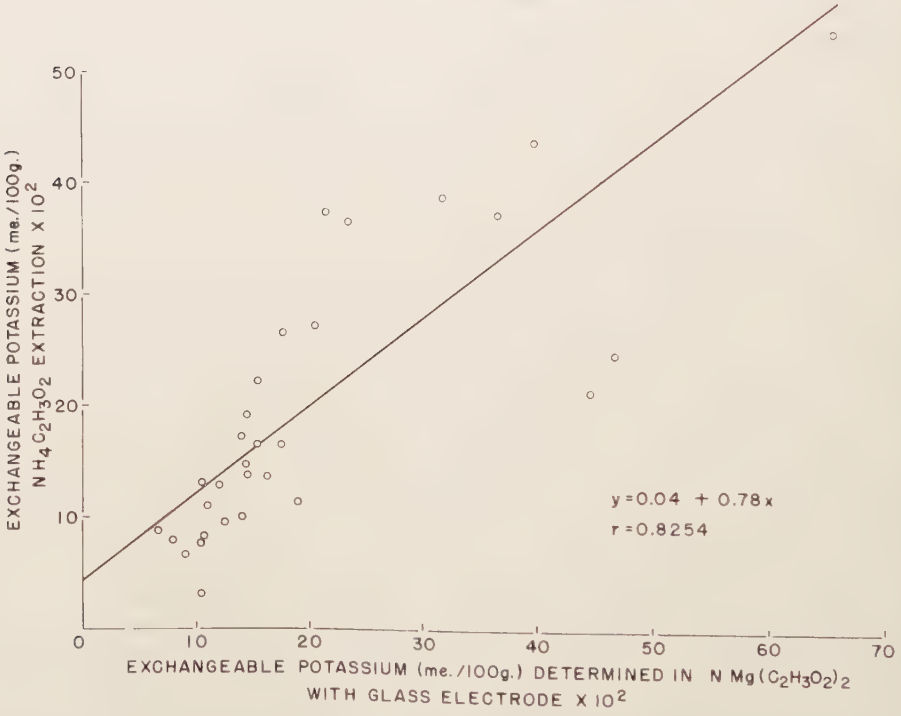

Fig. 4. Relationship between soil exchangeable potassium determined by the ammonium acetate method and with the Beckman cationic electrode.

Numerous investigators have shown a high correlation between exchangeable potassium and the uptake of potassium by plants showing exchangeable potassium to be a good indicator of the level of potassium fertility in soils. It follows then that a good soil test for potassium should measure this category of potassium or a portion

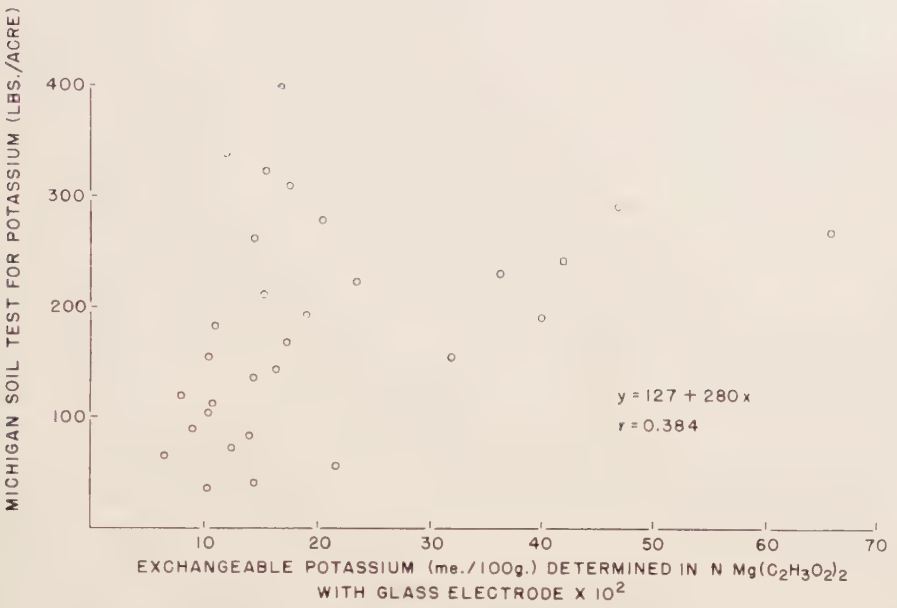

Fig. 5. Relationship between the Michigan soil test for potassium (0.13 NHCl extraction) and the exchangeable potassium as estimated with the Beckman cationic electrode.

thereof. The cationic-sensitive electrode used in this study can measure with some degree of accuracy the exchangeable potassium content of acid to neutral mineral soils. The simplicity of its use may commend its employment in soil testing laboratories, where extreme accuracy is not necessary and the equipment limited, since the analyses can be made on the same instrument used to estimate soil acidity, the pH meter. The fact that the only operation required is to shake up the soil-magnesium acetate mixture and insert the electrodes directly into the suspension without filtration suggests it may also save time in the analyses of large numbers of samples.

CONCLUSIONS

1. The cationic-sensitive electrode 78137V built by Beckman Instruments, Inc. may be used to estimate, with some degree of accuracy, the exchangeable potassium level of acid mineral soils.
2. There was a relatively poor relationship between exchangeable potassium determined by different methods and the soil test for available potassium.

3. The electrode was found to be not only sensitive to Li^+, Na^+, H^+, and K^+ ions, as suggested by Beckman Instruments Inc., but also to NH_4^+ ions.
4. The simplicity of the use of the glass electrode in estimating exchangeable potassium levels may commend its use in some soil testing laboratories.

TESTING FOR A DIFFERENCE BETWEEN TWO STRAINS OF SUGAR BEETS BY USE OF A DISCRIMINANT FUNCTION

By WILLIAM DOWELL BATEN[1] and HAROLD L. KOHLS[2]

DISCRIMINANT functions have been used in the past to discriminate between two composites made up of several characteristics of the objects under investigation. For example: testing for differences between spores when lengths and widths are given; testing between two compounds pertaining to potatoes grown in two states where flavor, mealiness, texture and color scores are considered; testing between two types of towels where compounds were made up of breaking strength for warp and filling, shrinkage for warp and filling and absorption were measured, etc.

The type of function used here shows how to test two single crosses of sugar beets by considering two composites made up of root weights, percents of sugar and percents of impurities of the two.

The data presented here come from two closely related crosses. 0636 and 2152 were male-steriles from the same single cross. The pollinators, 56 CLM-3 and 56 CLM-8, were two plants selected from the strain 54 EL-12. The first cross was .0636X 54 EL-12-38. The seed was taken from the male-sterile plant .0636, and 287 progeny were grown from that cross. The second cross, 2152X 54 EL-12-30, produced 318 progeny from the seed of the male-sterile 2152.

The seed was grown in aluminum foil tubes, one seed per tube, filled with Terra-Lite, and the seedlings thinned to one plant per tube. The seedlings were transplanted to the field in the 4-6 leaf stage and put in 28-inch rows and spaced 28 inches in the rows. They received the usual care during the growing season.

At harvest time in mid-October, they were lifted and weights were taken on root and top of each plant. In the laboratory each root was washed, weighted and analyzed for sugar and total water

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[2]Assistant professor, farm crops department, Mich. State Univ.

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soluble solids. Sugar and total solids were recorded in percent of root weight. The percents impurities were calculated by subtracting the percent sugar from the total solids.

The composite

$$X = b_1 x_1 + b_2 x_2 + b_3 x_3 ,$$

where x_1, x_2 and x_3 represent respectively root weight, percent sugar and percent impurities of the first strain, is to be compared with the composite

$$X' = b_1 x'_1 + b_2 x'_2 + b_3 x'_3 ,$$

where x'_1, x'_2 and x'_3 represent respectively the above measurements of the second strain and where the b's are the same in both composites. The values of the b's are to be found from the data from both strains.

The discriminant function, D, is the difference between the averages of these two composites.

To be able to determine D, it is necessary to solve three equations in the b's which are explained in Fisher's first article.[3] The solution of these equations leads to the values of the b's as

$$b_1 = -.00144,\ b_2 = .00693 \text{ and } b_3 = -.00308.$$

The arithmetic averages of the composites are

$$\bar{X} = -.00144\ (4.116) + .00693\ (12.246) - .00308\ (2.990)$$

and

$$\bar{X}' = -.00144\ (4.226) + .00693\ (9.986) - .00308\ (3.422)$$

The discriminant function is

$$D = \bar{X} - \bar{X}' = -0.00144\ (-.110) + .00693\ (2.260) - .00308\ (-.432) = .0172$$

The analysis of variance table for comparing the two composites is:

ANALYSES OF VARIANCE OF THE COMPOSITES OF THE 3 SETS OF MEASUREMENTS

Source of variation	DF	SS	M.Sq.
Total	99		
Between composites	3	$\frac{N_1 \cdot N_2(a)}{N_1 + N_2} D^2 = .0074$	.0025**
Within	96	D = .0172	.0002

(a) N_1 and N_2 represent the number of observed values respectively for each strain. Here $N_1 = N_2 = 50$.
** Significant at the 1 percent level.

[3]Fisher, R. A. The use of multiple measurements in taxonomic problems. Am. Eugen., 7, 1936. 179-188.

From the above table it is seen that there is a significant difference between the averages of the composites. This indicates that the first strain is significantly different than the second when root weight, percent of sugars and percent of impurities are considered. The absolute values of the coefficients in the discriminant function

$$D = -.00144\ (\overline{X}_1 - \overline{X}'_1) + .00693\ (\overline{X}_2 - \overline{X}'_2) - .00308\ (\overline{X}_3 - \overline{X}'_3)$$

indicate which of the variables is the most important, the next of importance and which is the least important in discriminating between these strains of sugar beets. The second coefficient .00693 is the largest; hence, percent of sugar was the most important for discriminating between these two strains. Percent of impurities is next in importance and root weight is the least important for discriminating between these two strains.

The discriminant function enables one to compare two compounds made up of several variables without testing for differences between the separate variables.

The literature on this subject is listed in the following references:

Baten, W. D., P. I. Tack and Helen A. Baeder. (January 1958). Testing for differences between methods of preparing fish by use of a discriminate function. Industrial Quality Control, Vol XIV.

Glenday, A. C. and S. O. Fejer (1956). The use of discriminant function in the relation of pasture plants, with particular reference to the Lolium species. Proceedings of the Seventh International Grassland Congress. pp 461-70.

A 1960 SURVEY OF MASTITIS IN THE LANSING MILK SHED

By A. R. DRURY and D. L. MURRAY

Department of Surgery and Medicine and Department of Dairy

At the time of the last mastitis survey in the Lansing area in 1939, Bryan found that 86 percent of the herds and 26 percent of the cows in these herds had mastitis. He further determined that 98 percent of the mastitis infections were associated with streptococci.

Since that time, many antibiotics and other chemotherapeutic agents have been used for the treatment of mastitis. It is felt that the widespread and promiscuous use of these antibiotics has resulted in neglect on the part of the dairy farmer insofar as management practices are concerned. In addition, the adulteration of milk with antibiotics either as a result of treatment of cows or from post-milking additions of them, has become a known public health problem.

In spite of the fact that these newer treatments have been extensively used, either prudently or otherwise, the mastitis problem not only persists but has increased in magnitude.

The information in this paper is the result of a study, suggested by a committee[1], to survey the status of mastitis in the Lansing area and to make recommendations for a complete mastitis program in the state of Michigan.

Procedures and Methods

Materials used for this survey consisted of: (1) Consecutive records from the mastitis laboratory, Department of Surgery and Medicine, consisting of the results on 25 herds during the fall of 1959. These do not include the university owned herds which are not representative of the average dairy farmer's herd since they are on a monthly

[1]The Interdepartmental Animal Communicable Disease subcommittee on mastitis was composed of Dr. G. L. Reed, veterinary pathology, M.S.U.; Dr. A. R. Drury, surgery and medicine, M.S.U.; W. W. Snyder, dairy department, M.S.U.; D. L. Murray, dairy department, M.S.U.; Dr. W. F. Buchele, agricultural engineering department, M.S.U.; K. Van Patten, dairy division, Michigan department of agriculture; Dr. D. B. Coohon, division of vital records and disease control, Michigan department of health; G. Parsons, dairy department, M.S.U., committee chairman.

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mastitis testing program. (2) Data obtained from herds supplying milk to a Lansing dairy plant. The project was discussed with the plant manager, and an alphabetical list of the shippers was provided. From this list every fifth producer was sent a form letter offering to sample milk from all the cows in his herd with the California Mastitis Test (CMT) (5) and to collect quarter milk samples for bacteriological study.

Results of the test on his herd were to be made available to the cooperator. Eighteen of the 25 farmers thus contacted showed a willingness to cooperate by returning their cards. One of these farmers refused to allow the testing when we arrived at the farm. One other returned the card stating he did not care to participate in the program. Cards were not returned by six farmers.

At each farm a fact sheet was filled out noting such things as type of housing, make of milking machine, number of units used, number of people milking, time lapse for milking, condition of equipment and general housekeeping. The CMT was run and aseptic quarter milk samples were collected from each milking cow. Additional information was recorded on stage of lactation, previous history of mastitis and recent treatments. The dairyman was asked his feelings in regards to the problem of mastitis and also how he handled the situation when flare-ups of mastitis occurred in the herd.

The CMT's were recorded as 4, 3, 2, 1, 0, as suggested by Drury (2) and from these an irritation index (II) was calculated. The II is determined by adding the CMT readings from each quarter of all milking cows and dividing the sum by the number of milking cows in the herd. The range can be from 0-16. The samples were brought to the laboratory for incubation, followed by direct microscopic examination of the incubated milk sample. Selected samples were cultured to make a classification more complete.

Result and Discussion

The survey involved 380 milking cows. The number of cows per herd varied from 10 to 51, with an average of 21 cows. Only one of the 18 herds was handled by loose housing and a milking parlor. The health department has stated this is about the ratio of stanchion to loose housing in this milk shed. There was one stanchion barn with a milk pipeline installation. Various makes of machines were used to milk the cows. One dairyman with 15 cows was using three units

and taking 1 hour to do his milking. A herd of 51 cows was milked with four units but two men were doing the entire procedure.

Fifteen of the 18 dairymen had strip cups. Only one used it routinely on each cow at every milking. One dairyman had his own CMT test kit but only used it sporadically. One farmer was employing veterinary service on a contractual basis while the rest were mainly home treating except for acute persistent attacks.

Of the 17 farms where samples were collected, only two dairymen were aware of cows that were giving abnormal milk on the day of our arrival. When the CMT results were examined, 19 quarters on 16 cows at 10 different farms gave a CMT 4, which is an abnormal milk and would be detectable on an ordinary strip cup.

The range of the II of the herds was from 2.0-10.5 (Table 1). The herd with a II of 2 had 25 infected animals out of 46 cows in the herd. The herd II of 10.5 had 13 out of 14 animals infected with significant microorganisms. The herd with the lowest number of infected quarters had a II of 3.8. The other herds with IIs below 3 were a 2.2, with six of 18 cows infected, involving 10 quarters out of 72, and the one at 2.8 with 20 of 30 cows infected and 34 quarters of 120 infected.

Of the 380 cows in the survey, 225 of them (59 percent) showed infection in one or more quarters (Table 1). The bacteriological status of the infected cows was as follows: 256 quarters (17 percent) of total quarters showed streptococcal organisms; 122 quarters (8 percent) showed staphylococcal organisms; three were coliform, one corynebacterium, two yeast infections, and one was pseudomonas. Of the infected quarters, 58.8 percent were strep., 39.4 percent were staph., leaving 1.8 percent as others.

The extent of infected animals ranged from a high of 13 out of 14 (92.9 percent) in one herd to a low of three of 15 (20 percent). Among the herds, the percent of quarters infected ranged from a high of 59 to a low of 5 percent.

One herd was on a vaccination program to help control mastitis, however 15 of the 23 cows had organisms characteristic of mastitis. Many of these cows had also been treated with intramuscular penicillin injections by the owner whenever any abnormal milk was noticed. One other herd had 23 of 30 animals infected with a record of nearly all cows having recent treatment with penicillin. The owner examined a record book in the barn and reported that six cows had even been treated the previous week with intramuscular injections of

TABLE 1—Summary of herds covered in 1960 survey

Herd identification	Number milking cows	Number inf. cows	Number qts. + strep	Number qts. + staph	Number of quarters CMT 4	Number of cows CMT 4	Irritation index	Remarks
A	30	20	29	5	4	3	2.8	
B	23	15	10	10	0	0	7.9	1 yeast
D_1	11	6	3	8	1	1	6.4	All cows vac.
D_2	15	3	3	0	0	0	3.8	
E	18	6	8	2	0	0	2.2	
G	17	10	4	13	0	0	6.6	
K	46	25	39	10	1	1	2.0	1 colif
M_1	14	13	24	8	2	2	10.5	1 colif
M_2	51	35	32	24	1	1	6.0	1 yeast, 1 colif
N	15	12	18	5	0	0	4.2	1 pseud
P	26	18	26	14	1	1	6.0	1 coryne
R	30	23	32	8	3	2	5.9	
W_1	16	8	12	3	3	2	6.3	
W_2	19	4	1	3	0	0	4.0	
W_3	10	7	9	3	1	1	4.3	
S_1	19	11	14	4	2	2	5.8	2 pseud
V	20	9	11	2	0	0	5.0	
S_2	Refused to have cows sampled upon arrival at farm.							
Totals	380	225	256	122	19	16	9	

Summary of Survey for Mastitis

Date	Number of herds	Number of cows	Percent herds inf.	Percent cows inf.	Percent strep. inf. qts.	Percent staph. inf. qts.	Percent other inf.	Average number of cows per herd
1939(*a*)	322	2715	86	26	98	NA(*e*)	2(*d*)	8.9
1959(*b*)	25	786	96	49.8	63.1	33.3	3.6	31
1960(*c*)	18	380	100	59	58.8	39.4	1.8	21

Date	Number of quarters strep	Percent total qts.	Number quarter staph	Percent of total staph	Percent of other infections
1939	NA(*e*)	NA(*e*)	NA(*e*)	NA(*e*)	NA(*e*)
1959	337	10.7	178	5.6	1.3
1960	265	17.4	122	8.1	1.8

(*a*) Bryan Survey.
(*b*) Mastitis Laboratory Record 1959.
(*c*) Present Survey.
(*d*) At the time of this survey, staphs were included under other category.
(*e*) not available.

antibiotics. All these treated animals shed significant organisms at the time of our survey as shown by the laboratory results.

Of all 18 farms visited there were only two where the housekeeping was exemplary in terms of appearance of cows, barns, milkhouses and care of milking machines. There were only three farms that had had their milking machines serviced by the dealer within 6 months previous to the visit for the survey.

The survey of this same area in 1939, carried out by former Dean C. S. Bryan (1), covered 322 herds with 2715 cows. At that time, 86 percent of the herds and 26 percent of the cows were infected. Ninety-eight percent of the infections were Streptococci and 2 percent were others. At the time of the Bryan survey, antibiotics or sulfonamides had only been used in a very limited amount for treating mastitis.

The mastitis laboratory consecutive records on 25 herds (Department of Surgery and Medicine) totalling 786 cows showed that 96 percent of the herds had infected animals. Nearly half (49.8 percent) of the cows were infected in one or more quarters. This included 337 quarters with streptococcal infection or 10.7 percent of all quarters. There were 178 quarters with staphylococcal infection or 5.6 percent of all quarters. There were 9 quarters with other organisms. Amongst them were coliform, corynebacterium, pseudomonas and yeast organisms. Of the infected quarters, 63.1 percent were streptococcal, 33.3 percent were staphylococcal and 3.6 percent were others. Most of these 25 herds were thought to have infected animals prior to the sampling, or samples from the herds would not have been collected. Therefore, it would be expected that the incidence would be higher than the random survey.

The DHIA records for 1959 were examined for the purpose of ascertaining why certain cows were eliminated from the herd. Accordingly, 7.7 percent of the animals were checked as having mastitis as the reason for leaving the herd (4). Low production (43.5 percent) was given as the predominant reason for selling a cow, however mastitis might well have been responsible for the low production in many of these cows. Also no tests were made to determine status of the udder prior to the sale.

There is still a big mastitis problem in spite of the great amount of money spent for antibiotics and vaccinations. A new program is needed on the farm, even if it only involves carrying out the many known but sadly neglected management practices that should minimize this disease. Also, such mechanical aspects as general condition, operation, and care of the equipment are thought to be of major significance in the prevention and control of mastitis. Proper inventory encompassing diagnosis and management practices will aid in a solution to this problem especially when supported by judicious treatment.

The loss occurring from mastitis is incalculable because it involves loss of production, as well as loss of butterfat during progress of an

undiagnosed mastitis infection. Some cows even die during an acute attack; many more are permanently damaged so that they are inefficient producers when retained in the herd and eventually go to slaughter as low producers. The losses are further compounded by the cost of medicine to treat infected cows and the milk which must be discarded following the treatment of a cow.

Mastitis cannot be eliminated entirely because of its complex nature but it certainly can be minimized by good sound prevention and control practices. This has been demonstrated by use of herds in various Michigan counties through cooperative programs carried out by county agents, veterinary extension specialists, dairy extension specialists and the mastitis research laboratory in the Department of Surgery and Medicine.

Mastitis prevention and control recommendations are included in Michigan State University Extension Bulletin 334, "Mastitis control in Michigan herds."

SUMMARY

Mastitis is increasing in dairy herds as indicated by the surveys. The ratio of prevailing organisms from the udder is changing from a predominantly streptococcal flora to a 2-1 ratio of streptococcal, staphylococcal etiological agent. The number of cows in the herds in the Lansing area, as shown by the surveys, has increased from an average of 8.9 in 1939 to 21 in 1960.

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RELATIVE CLEANABILITY OF STAINLESS STEEL TUBING AND MILK DISPENSER CANS HAVING VARIOUS FINISHES[1]

By O. W. KAUFMANN, T. I. HEDRICK, I. J. PFLUG and C. G. PHEIL

Departments of Microbiology and Public Health and Food Science

INTRODUCTION

The cleanability of stainless steel surfaces in contact with milk during handling and processing is of importance to the dairy industry, public health officials, detergent manufacturers, and others. Until recently, the role of the finish, with respect to cleanability, has been studied almost entirely by observing the visual appearance of the surface.

This study is a continuation of an exhaustive investigation which was undertaken to determine the relative cleanability of various stainless steel finishes used in the fabrication of five representative types of milk processing equipment. Specifically, the purpose of this study was two-fold: (a) to ascertain the relative cleanability of stainless steel tubing finish that approximates No. 2 (bright annealed), 4 and 7 of sheet finishes used to handle hot and cold milk and (b) to make the same evaluation of a No. 2B, 3, 4 and 7 finish on stainless steel milk dispenser cans. The trials were conducted under carefully observed plant operating conditions using commercial equipment and recommended cleaning procedures.

Previous reports indicate there is no significant difference in relative bacterial cleanability of No. 2B, 3, 4 and 7 finishes in laboratory trials using 8 x 8-inch panels (2), high temperature short time pasteurization unit (HTST) and a pasteurizing vat (3), and farm bulk tank (4). Masurovsky and Jordan (5) have reported total average residual equivalent bacterial populations of 520, 510, 510 and 480 on No. 2B, 3, 4 and 7 finishes of stainless steel, respectively. On the basis

[1]This project was supported in part by the American Iron and Steel Institute and the National Association of Dairy Equipment Manufacturers.

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of a Chi Square Test applied to these data no significant difference in cleanability is indicated.

EXPERIMENTAL

Description of Equipment

Cans. Six cans of each finish containing sidewalls having a No. 2B, 3, 4 and 7 finish were used in this study. The area tested comprised the sidewall since the bottom, shoulder and neck were drawn from the same finish but might not be equivalent to the test surfaces under the study. To minimize the variations contributed by the welded areas, seams were polished comparable to a No. 4 finish.

Pipelines. One and one-half inch stainless steel tubing with representative finish that approximates No. 2 (bright annealed), 4 and 7 of sheet finishes was used in these trials. For the cold milk tubing studies, two sections of each finish, 8 to 12 feet long, were placed in the regular lines between the storage vats (receiving) and the balance tank ahead of the HTST press. For hot milk lines the holding tube of a HTST system was used. Duplicate sections, 51 in. long of each finish were placed in this unit.

Soiling Procedures

Cans. The cans were soiled by filling with cold (40° F) pasteurized, homogenized milk that had been standardized to 3.5 percent milk fat. After standing for 2 minutes, the cans were emptied, inverted and drained for 10 minutes. To assure a high level of bacterial contamination, comparable to that which might occur under some commercial conditions, the cans were stored for 18-24 hours at 98°F.

Pipelines. The stainless steel tubing was substituted for sections of the regular sanitary pipeline in the M.S.U. Dairy Plant. The cold raw milk line was soiled by pumping whole milk or skim milk at 38-42°F through the system for 5 to 7 hours each day. The flow rate was approximately 7500 pounds per hour. The cold milk line was in use 4 months before testing was initiated. Hot milk soiling was accomplished by replacing six sections of the holding tube with the test tubing. The flow rate was 7500 pounds per hour for a period of 5 to 6 hours. The temperature of the milk in the holding tube was approximately 165°F. This unit was in operation for 2 months prior to beginning the bacteriological examination.

Cleaning Procedures

Cans. The water used in all studies was approximately 10 ppm in hardness. A straight-line can washer was used to clean the cans. The cleaning cycle consisted of several steps — prerinse, wash, flush, hot water rinse, steaming and hot air. The washer was fed at the rate of six cans per minute, the maximum rate recommended by the manufacturer.

In the first step the cans were prerinsed with a jet of water at 55°F. for 14 seconds at the rate of 155 g.p.h. This treatment seemed to remove loose soil effectively as indicated by the visual appearance of the rinse water at the end of the rinsing. In the second step the cans were washed with a chlorinated alkaline detergent solution (1 oz per 3 gal. water) at 160-165°F. for 11 seconds. In this treatment the flow rate was 1,440 g.p.h. Automatic feeder systems were used to maintain the alkalinity and chlorine levels at 2,500 and 240 ppm, respectively. Immediately after washing the detergent solution was flushed from the can using hot water at 170°-175°F. Flushing was carried out for 12 seconds at the rate of 1750 g.p.h. Another water rinse at 200°-205°F. was given for 12 seconds. The cleaning treatments described in the preceding steps constitute T-1. The final steps in the cleaning cycle consisted of steaming for 12 seconds and then blowing filtered air at 225°F. into the can for 12 seconds at the rate of 25 c.f.m. Cans receiving all the treatments are referred to as T-2.

Pipelines. The cold raw milk pipelines were cleaned on a separate circuit by a cleaned in place (CIP) method. The line was prerinsed for 3 minutes with water at 115-125°F. Detergent washing was accomplished by recirculating a commercial alkaline cleaner (1 oz. per gal.) for 15 minutes at 160°F. After six soilings, an acid detergent (1 oz. per 2 gal.) was used in lieu of the alkaline solution. After washing, the detergent was drained and the tubing flushed for 3 minutes with water at 115-125°F. Bacteriological tests were undertaken immediately on the cold milk lines without sanitization.

The hot milk line was cleaned as part of a circuit that included the HTST press, flow diversion valve, steam infuser, vacuum chamber, homogenizer, and connecting pipeline. Upon completion of processing, the line was prerinsed for 10 minutes with water at 162°F. An acid detergent solution at 175°F (5 pints in 70 gal.) was recirculated for 30 minutes. Following this, a slurry of an alkaline detergent, in the proportion of 5 lbs. per 70 gal. of solution was added directly

to the acid solution. Recirculation at 175°F. was continued for 30 minutes. The wash solution was flushed from the system with water at 162°F for 15 minutes. The surfaces were tested 16 to 18 hours after washing, but before sanitizing.

Testing Procedures

Cans. Modified rinse and swab techniques were used to evaluate the bacteriological cleanability of each can. In the rinse test (1), 500 ml of sterile phosphate buffer (pH 7.0) was added aseptically to each can. The area exposed in the rinse test was 600 square inches; this represents the entire surface of the sidewall. In testing, the can was placed horizontally on rollers and rotated at 35 r.p.m. for 4 minutes to provide complete coverage of the surface and some agitation. This speed was selected as it provided some turbulence and agitation of the rinse solution to aid in the removal of bacteria on the sidewall. At the end of the 4-minute period, the rinse solution was aseptically returned by a closed system to the original container and held at 39°F. until plated. Standard plate count agar containing 0.5 percent additional agar was used to prepare five plates, each containing 10 ml of rinse solution. Counts were made after incubation at 98°F. for 48 hours. A series of three cans of each finish was tested after treatments T-1 and T-2. The results in Table 1 are expressed as the total number of bacteria recovered per can (500 ml. of rinse solution).

A modified swab test using a large swab as described by Kaufmann *et al* (4) was also used to study the bacterial cleanability of the dis-

TABLE 1—Bacterial counts of can surface after various cleaning treatments—rinse test

(600 square inches)

Trial number	After washing (T-1) Finish of stainless steel				After steaming and hot air drying (T-2) Finish of stainless steel			
	2B	3	4	7	2B	3	4	7
1	(a)220	(a)300	(a)277	(a)227	(a)266	(a)313	(a)440	(a)147
2	147	310	183	123	70	310	73	157
3	423	563	140	523	83	47	70	143
4	160	223	137	140	53	93	73	50
5	110	143	130	160	53	170	50	60
6	123	63	73	133	36	93	67	87
7	127	193	113	190	30	60	70	160
8	77	110	113	357	23	40	60	60
9	73	137	87	347	33	50	40	43
Grand Average	161	223	139	241	72	127	106	101

(a) These values represent the average of three replications.

penser can. A 5-inch strip around the circumference of the can was tested in this study; this represented 200 sq. in. The moistened swab was rubbed over the test area three times and placed in a 500 ml bottle containing 50 ml of sterile phosphate buffer. The bottle was shaken 25 times and duplicate 10 ml samples were plated using the same medium as above. Counts were made after incubation at 98°F. for 48 hours. The results shown in Table 2 are expressed as the number of organisms recovered from 200 sq. in.

TABLE 2—Bacterial counts of can surface after various cleaning treatments—swab test

(200 square inches)

Trial number	After washing (T-1) Finish of stainless steel				After steaming and hot air drying (T-2) Finish of stainless steel			
	2B	3	4	7	2B	3	4	7
1	(a)22	(a)32	(a)19	(a)13	(a)40	(a)19	(a)53	(a)51
2	97	146	132	75	70	143	98	70
3	150	183	75	228	57	55	75	115
4	29	47	29	37	46	58	49	31
5	21	33	46	44	30	44	67	13
6	29	13	19	41	15	16	17	22
7	40	31	37	45	22	84	75	24
8	12	25	15	17	7	13	21	17
9	25	47	36	21	40	29	25	52
Grand Average	48	62	45	58	36	51	53	44

(a) These values represent the average of three replications.

Pipelines. The number of bacteria remaining on the surface of the hot and cold lines were determined by a rinse test. In making this test the clamps at the unions were removed and the fittings swabbed with alcohol and flamed to reduce the possibility of contamination from these sources. Immediately after flaming, the ends of each tube were plugged with sterile rubber stoppers. One rubber stopper was fitted to permit 500 ml of sterile rinse solution to be added aseptically. To assist in removing organisms from the interior surface, the tubing was rotated and manipulated in such a manner that the solution flowed to each end 60 times in about 3 minutes. The pipe also was held horizontally and shaken 120 times through an arc of 8 inches in 1 minute.

Following this, the tube was again rotated and manipulated as described above. The rinse solution was drained into the original container under aseptic conditions. One hundred milliliters of the rinse solution was plated, using 10 ml. in each of 10 plates. Standard

plate agar was used with an additional 0.5 percent agar. The incubation temperature was 90°F. The results shown in Table 3 are expressed as number of organisms per 40 sq. in. of tubing.

TABLE 3—Bacteria counts on cold milk lines with the rinse test(a)

(Based on a 40 sq. in. area(b))

Trial number	Finish of stainless steel		
	2	4	7
1	208	276	216
2	26	44	66
3	36	20	120
4	21	14	38
5	22	30	1
6	64	2	432
7	112	316	120
8	124	8	96
9	292	168	184
10	72	14	68
11	52	64	36
12	59	91	6
13	95	158	54
14	22	40	31
15	20	38	19
16	32	2	15
17	20	18	18
Average	75	76	89

(a) All counts made prior to sanitization.
(b) Suggested maximum standard is 500 per 40 square inches.

RESULTS AND DISCUSSION

Cans. The bacteriological results obtained with the rinse test and the large swab test are given in Tables 1 and 2, respectively. These data represent the average value based on the results obtained from three different cans of each finish. An analysis of variance was used to test the relative bacterial cleanability of the various finishes after comparable conditions of soiling and cleaning. On the basis of the rinse test, an analysis of variance of the individual replications indicated no significant difference at the 5 percent level in the cleanability of a No. 2B, 3, 4 and 7 finish after cleaning treatments T-1 or T-2. Similar findings were observed with the swab test. It is im-

TABLE 4—Bacteria counts on tubing soiled by hot milk(a)

(Based on a 40 sq. in. area(b)

Trial number	Finish of stainless steel		
	2	4	7
1	7(c)	14(c)	12(c)
2	5	12	18
3	5	9	14
4	16	25	73
5	50	45	55
6	19	21	19
7	14	23	23
8	9	22	18
9	25	34	41
10	14	25	23
Average	16	22	29

(a) All counts made prior to sanitization.
(b) The maximum recommended standard is 500 per 40 square inches.
(c) These values represent the average of two replications.

portant to note that in the rinse test the entire 600 sq. in. comprising the sidewall are examined, whereas, with the swab test only 200 sq. in. of surface are evaluated.

On the basis of the rinse test, the grand average bacterial counts on the No. 2B, 3, 4 and 7 finish were 161, 223, 139 and 241 per sidewall, respectively, after washing (T-1). After treatment with steam and drying (T-2), the grand average counts on the above finishes were 72, 127, 106 and 101, respectively. With the swab test, the grand average counts on these finishes after treatments T-1 and T-2 were 48, 62, 45 and 58, and 36, 51, 53 and 44, respectively. The counts obtained after swabbing represent the bacteria actually removed due to the scrubbing action of the swab procedure as well as the microorganisms present in the residual film of rinse solution which remained after draining. The organisms contributed to the swab test from the residual rinse were calculated to be in the order of 10 per test area. This represents from 15-20 percent of the value given in Table 2. The additional number recovered by the swab test is important and for these trials indicates the possible superiority of the swab test over the rinse procedure.

If one assumes homogeneous distribution of soil, it is possible to convert the data obtained with the swab test on 200 sq. in. to include

the entire sidewall (600 sq. in.). On the basis of the counts given in Table 2, these calculated average values are 142, 186, 136 and 174 after T-1 and 109, 165, 160 and 132 after T-2. Coincidently, the values obtained with the swab test calculated to 600 sq. in. of surface compare favorably with those obtained with the rinse test.

In actuality, however, the swab test was undertaken on a portion of same surface after the rinse test had been completed. Since the swab test represents an additional test done on a portion of the same surface, it follows that the results of the two tests are cumulative. This final total represents the total calculated number of bacteria recovered from the sidewall. After washing, the calculated total average counts on No. 2B, 3, 4 and 7 finish were 305, 409, 274 and 415, respectively. After steaming and drying these values were 180, 280, 265 and 233, respectively. Compliance with the maximum recommended standard (1) was observed on each finish incorporated in the sidewall.

Pipelines. The bacteriological data on the cold milk lines are given in Table 3. When the recommended cleaning cycle, as described above, was used, an analysis of variance indicates no significant difference in the bacteriological cleanability among the No. 2 (bright annealed), 4 or 7 finishes. The average values calculated on the basis of 40 sq. in. of surface are 75, 76 and 89 on the 2, 4 and 7 finishes, respectively, and compliance with the maximum recommended standard of 500 per 40 sq. in. was observed with all finishes.

The cold milk lines were also tested after a minimal cleaning cycle. Notwithstanding the improper cleaning treatment, an analysis of variance indicates no significant difference in relative bacterial cleanability when the No. 2, 4 or 7 finishes are compared. The grand average values, based on 22 replications, obtained on the No. 2, 4 and 7 finishes are 1197, 4394 and 3096 per 40 sq. in., respectively. Compliance with the maximum recommended standard of 500 per 40 sq. in. was observed 50, 36 and 64 percent of the time with the No. 2, 4 and 7 finishes, respectively. In studies on pipelines, Masurovsky and Jordan (5) using a limited ultrasonic cleaning technique, reported total average residual equivalent bacterial populations of 33, 37 and 30 ($X10^{-3}$) on standard surface Pyrex pipe, 120, and 180 grit stainless steel tubing, respectively. The close agreement shown in these figures may be interpreted to indicate no difference in cleanability under the conditions utilized in this experimental design.

The bacteriological results on the hot milk lines are given in

Table 4. An analysis of variance on the individual replicates indicates a significant difference at the 5 percent level in the bacteriological cleanability of the three finishes. The Multiple Range Test of Duncan indicates that the No. 7 finish is significantly different from the No. 2 and 4 finishes. The grand average bacterial counts per 40 sq. in. of surface on the No. 2, 4 and 7 finishes are 16, 22 and 29, respectively. Compliance with the maximum recommended standards was also observed 100 percent of the time.

The results obtained on the hot milk lines differ from those reported on a HTST unit and a vat pasteurizer which showed no significant difference (3). Since the HTST unit and the hot milk lines were soiled and cleaned simultaneously under the same conditions, one might expect similar results. Two factors, however, may be responsible for the difference observed: (a) a slight change in actual finish brought about in the rolling of tubing or (b) application of a different test procedure. The inefficiency of the rinse test in removing bacteria on a surface has been indicated in the can studies; the extent to which this may influence the findings requires further investigation. The difference in the results obtained in the pasteurizing vat as compared with the hot milk lines might be explained by the fact that soil deposition was variable in the former (3). This uneven deposition of soil made a comparison of surfaces difficult. In the previous studies (3), the wash procedure was sufficient to clean the most soiled surface; this may have resulted in the application of an excessive cleaning procedure on the surfaces containing less soil.

SUMMARY AND CONCLUSIONS

In testing the sidewalls of dispenser cans fabricated from stainless steel having No. 2B, 3, 4 and 7 finishes, no significant difference in bacteriological cleanability was noted.

When soiled by cold raw milk there was no significant difference in the bacteriological cleanability of stainless steel tubing finished comparable to No. 2 (bright annealed) 4 or 7 finish of stainless steel.

The results of standard plate counts on rinse tests of the same finishes when cleaned after soiling with milk at 165°F. showed no significant difference between No. 2 (bright annealed) and 4 finishes; but 7 was significantly different.

The results of this study on relative cleanability of milk tubing and dispenser cans, except for hot milk lines, confirm the results on

HTST plates and pasteurizing vat (3) and farm bulk tank (4). In all cases the influence of other factors on cleanability of stainless steel is much more important than the effect of finish.

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EFFECT OF DIETARY FAT LEVELS UPON REPRODUCTIVE PERFORMANCE OF MINK

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INTRODUCTION

IT IS GENERALLY BELIEVED by ranchers that mink must receive diets relatively low in fat for optimum performance during breeding, gestation, parturition and lactation, as well as during early kit growth. While most successful ranchers feed low-fat rations to their mink, there have been no controlled attempts to determine the validity of this belief.

Experiments were conducted to investigate this problem during two reproductive seasons. In 1957, 40 female and 40 male natural dark breeder mink were used and in 1958, 30 female and 15 male mink of the same type were used. The relatively low-fat control ration consisted of 26⅔ percent each of horse meat and bone, tripe and ocean perch with 15 percent of supplemental cereal and five percent of fresh liver. The control ration, during both years, contained about 23 percent of fat on a moisture-free basis. As shown in Table 1, the addition of fat produced diets 8 percent higher in fat than the control diet for the 1957 experiment and 12 and 21 percent higher, respectively, for the 1958 test.

In 1957, the females were kept in slender breeding condition while in 1958, an attempt was made only to maintain their weight. Table 2 shows that it was difficult to maintain body weight on the rations containing the highest fat level.

Results and Discussion

Breeding and reproductive results, as well as weights of breeders and kits, are shown in Table 3. Mating performance of the males was comparable irrespective of fat levels. Within practical limits, males

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TABLE 1—Percentage composition of experimental mink rations in 1957 and 1958

	Diet	Moisture	Protein	Fat	Fiber	Calcium	Phosphorus
Moisture-free basis							
1957 Control	A	0	40.1	23.2	2.3	1.9	1.4
1957	B	0	39.8	31.4	2.2	2.3	1.5
1958 Control	C	0	42.1	22.7	2.5	1.9	1.3
1958	D	0	36.3	35.2	1.9	1.6	1.1
1958	E	0	30.7	44.1	1.8	1.1	.9
"As fed" basis							
1957 Control	A	69.8	12.1	7.0	.70	.57	.41
1957	B	67.7	12.0	9.5	.66	.69	.44
1958	C	73.6	11.1	6.0	.66	.50	.35
1958	D	71.9	10.2	9.9	.54	.44	.32
1958	E	68.5	9.7	13.9	.58	.34	.27

TABLE 2—Weights (gms) of female mink fed diets containing different levels of fat

Approximate fat level %	Jan. 2	Jan. 18	Mar. 11	Mar. 20
1957 experiment				
23	...	776	708	...
31	...	790	722	...
1958 experiment				
23	790	...	...	776
35	790	...	...	792
44	805	...	...	842

TABLE 3—Mating performance of male mink receiving rations containing different fat levels

Approximate percent fat	No. males		No. males breeding		No. matings	
	Adult	Kit	Adult	Kit	Adult	Kit
1957 experiment						
23	8	12	8	9	36	33
31	8	12	8	10	37	49
1958 experiment						
23	2	3	2	3	6	9
35	2	3	2	1	10	1
44	2	3	1	3	3	15

fed different rations were given an equal opportunity for mating. During the first year, the mating performance of adult and kit males was satisfactory and unrelated to fat levels. In 1958, the young male breeders on the 35 percent fat ration did not perform very well. However, the kit males receiving the 44-percent-fat level mated well so performance was probably not related to the amount of fat in the diet.

Analysis of variance showed that there were no significant differences among mink on different fat levels with respect to the number of females breeding and whelping or in the number of kits born or alive at the end of the experiment (Table 4). The one-day-old kits of mothers on the 31 percent fat level were significantly smaller ($P < 0.01$) than those of mothers on the control ration in the 1957 study (Table 5). However, there was no significant difference at 21 days or at either 1 or 14 day weights in the 1958 study.

From these studies, it would appear that mink have a remarkable capacity to utilize fat. The 44-percent-fat ration contained over 67 percent of its calories in the form of fat. As might be expected, food consumption was reduced in the lots fed the higher fat rations. In the 1958 studies, mink on the 35-percent-fat ration ate 13 percent less food, and the mink on the 44-percent-fat ration ate 21 percent less food than the controls (2-months food consumption). The actual difference was probably greater than this because mink on the control ration lost weight slightly while those on the highest fat level gained slightly.

The fact that reproductive performance was good with rations high in fat indicates that the typical ranch ration had an excess of

TABLE 4—Whelping results and kit performance of mink during 1957 and 1958

Approx. percent fat	No. females	No. bred	No. whelped	Kits born	Kits alive at			Mortality(a) percent	Kits alive at 1 day	
					1 day	14 days	21 days		Per female kept	Per female whelping
1957 experiment										
23	20	20	17	97	92	..	87	10	4.6	5.4
31	20	19	17	98	98	..	83	15	4.9	5.8
1958 experiment										
23	10	10	10	71	60	50	..	30	6.0	6.0
35	10	10	9	65	60	48	..	26	6.0	6.7
44	10	10	10	67	64	45	..	33	6.4	6.4

(a) Includes kits born dead and deaths to 14 or 21 days.

TABLE 5—The average 1-day to 21-day weights of mink kits, in grams

Approx. percent fat in mothers diet	At 1 day			At 14 days			At 21 days		
	Male	Female	Av.	Male	Female	Av.	Male	Female	Av.
1957 experiment									
23	10.5	9.9	10.2	....	....	....	111	105	108
31	9.5	9.1	9.3	....	....	....	113	100	106
1958 experiment									
23	8.6	8.2	8.4	59.2	54.9	57.1	....	....	....
35	9.2	8.4	8.9	60.5	56.2	58.4	....	....	....
44	8.9	8.5	8.7	58.9	55.3	57.1	....	....	....

the other nutrients. It will be possible, therefore, to formulate diets lower in protein, vitamins and minerals than presently used in practical rations when more information is available on the nutritional requirements of these animals. These new rations would be more efficient and more economical. It should be kept in mind that other strains of mink, such as sapphire, may possibly differ from darks in their ability to absorb and utilize food.

Possibly the belief among mink ranchers that low-fat foods should be used during the reproductive cycle is due to the harmful effects of improper storage on fat rather than high levels of fat per se. The oxidation of unsaturated fats destroys certain vitamins, such as vitamin E and thiamine and this could lead to multiple vitamin deficiency diseases. Such difficulties would be prevented by practicing short-time storage of food and food ingredients, the use of anti-oxidants in high-fat foods and the use of efficient low-temperature freezers for storing foodstuffs.

Summary and Conclusions

A study was conducted during two reproductive cycles on dark mink to determine the effects of dietary fat levels upon reproductive performance of mink. A total of 523 mink was used: 80 adult and 195 kits in 1957 and 45 adults and 203 kits in 1958.

Diets with fat levels ranging from 23 to 44 percent on a moisture-free basis gave comparable results during breeding, gestation, parturition and early kit growth.

Food consumption was decreased markedly when the fat level of the ration was increased.

It is concluded that fat levels in the diet do not need to be as low as presently believed necessary by mink ranchers, providing the fat is of high quality.

HEAT PROCESSING CHARACTERISTICS OF FRESH CUCUMBER PICKLE PRODUCTS

II. Heating Rates of Whole Pickles

By R. C. NICHOLAS and I. J. PFLUG

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This report, covering whole pickles only, is the second of a series treating the heating characteristics of fresh cucumber pickle products. Because of the large number of possible products, only a limited number were tested; however, the important variables that affect heating characteristics have been examined; namely, variation in jar size and nature of the covering liquor.

Whole pickles constitute the largest fresh cucumber pickle item and therefore have received considerable research attention (1, 2, 3, 4, 5). The whole pickle product, whether sweet or sour, is one of the easiest products to pasteurize from rate of heating point of view; however, certain sections of the industry are still troubled with spoilage of this product.

It is the purpose of this study to develop additional knowledge regarding the heating characteristics of whole pickle products as affected by commonly encountered variables in the hope that this will provide the knowledge which will make possible a more rational pickle pasteurization process design.

EXPERIMENTAL

Jars chosen for this study are representative of those used for actual pickle packs. (The specifications of jars used are given in Table 1.) The cucumbers used in the laboratory packs were washed for 5 minutes in a tumble-action washing machine, blanched for 5 minutes in 150°F water, packed by hand into the jars to a specified weight, covered with 135°F brine (1.4% acetic acid, 4.0% salt, unless otherwise specified), sealed and heat processed in a water bath.

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TABLE 1—Container dimensions

Name	Normal fill oz.(a)	Outside diameter in.	Height to top of finish, in.	Jar weight, oz.	Thermocouple distance from bottom of jar, in.
Vegetable jar (No. 303)..	16	3.00	4.75	7.1	0.9
Cylinder.....	16	2.88	5.50	9.1	1.0
Cylinder.....	22	3.00	7.25	12.9	1.4
Regular quart(*b*).....	32	3.62	7.12	13.1	1.3
Regular ½ gallon.....	64	4.88	8.60	23.5	1.3
Regular gallon.....	128	6.31	10.0	39.5	1.7

(a) Overflow capacity about ½ oz. more.
(*b*) Newer, square-shouldered quarts may give different results.

Water bath temperature control and temperature measuring equipment have been previously described (7). Commercially packed jars (line packs) were prepared by a procedure that did not differ appreciably from the routine described above.

RESULTS AND DISCUSSION

The entire analysis of the heating data involves a discussion of heating rate, f_h, and lag factor, j, obtained by standard methods discussed in the first paper of this series (7).

The results of a test comparing the heating characteristics of No. 1 pickles (less than 1 1/16-in. diameter) in 16-oz. vegetable and 16-oz. cylinder jars are given in Table 2; the 16-oz. cylinder is a slightly taller jar with smaller diameter. No significant difference was found between the heating rates or lag factors of this product in these two types of jars; however, the comparison may not be strictly justified because the data for 16-oz. cylinder jars were from a line pack and

TABLE 2—Comparison of heating characteristics in two different 16-oz. jar shapes (whole No. 1 cucumbers in brine, 1956)

Jar type	No. jars in test	Fill ratio	Lag factor (j)				Heating rate (f_h) min.			
			Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
16-oz. cyl..	16	LP(*a*)	1.22	1.06	1.45	0.14	17.0	13.6	20.3	1.59
16-oz. veg..	6	0.62	1.14	0.89	1.34		17.6	15.9	19.6	

(*a*) Line pack

the 16-oz. vegetable jars were hand packed with a fill ratio[1] of 0.62 which is believed to be close to the line pack fill ratio.

Small whole pickles may be packed in a sweet liquor or in brine; the products are known respectively as sweet gherkins and midget dills. A comparison of the heating characteristics of these two products in jars of the same geometry is given in Table 3. No significant difference was found between the heating rates or lag factors for the two packs.

TABLE 3—Effect of covering liquor on heating characteristics of whole No. 1 cucumbers, syrup vs. brine, (line packs, 16-oz. cylinder jars, 1957)

Liquor	No. jars in test	Lag factor (j)				Heating rate (f_h) min.			
		Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
Brine.....	8	1.13	1.00	1.44	0.16	17.5	13.8	21.8	3.01
Syrup.....	15	1.17	1.04	1.30	0.09	17.6	13.8	20.7	1.5

The data from these two tests can be used to illustrate one of the perennial problems of the pickle packer: whether to base temperature reached (or desired) in the heat process on the brine temperature or on the temperature inside the cucumber. The thermocouple location, whether inside or outside a cucumber, was determined after the tests (16 jars were examined, 8 of the brine packs and 8 of the syrup packs). In 10 cases (five from each test) the thermocouple happened to be inside a cucumber and in 6 cases outside (approximately in the same proportion as cucumber volume to brine volume). These data were analyzed on the basis of location of the thermocouple, and the heating rates were found to be significantly different at the 1 percent level, the heating rate (f_h) inside the cucumber being larger. The lag factor for a point inside a cucumber was larger than for a point outside, but the difference was not significant. Figure 1 shows two curves for a point in the region of the slowest heating point in the jar based on average f_h's and j's, one curve inside a cucumber and one outside a cucumber.

Suppose a heating process is being monitored by keeping a record of temperatures reached in the jar after a fixed time in the pasteurizer. If all the measurements are made in the brine (outside the pickle), then the average temperature measured will be higher than the true temperature inside the cucumber. If no effort is made to distinguish

[1]Ratio of product weight in ounces to jar capacity in ounces.

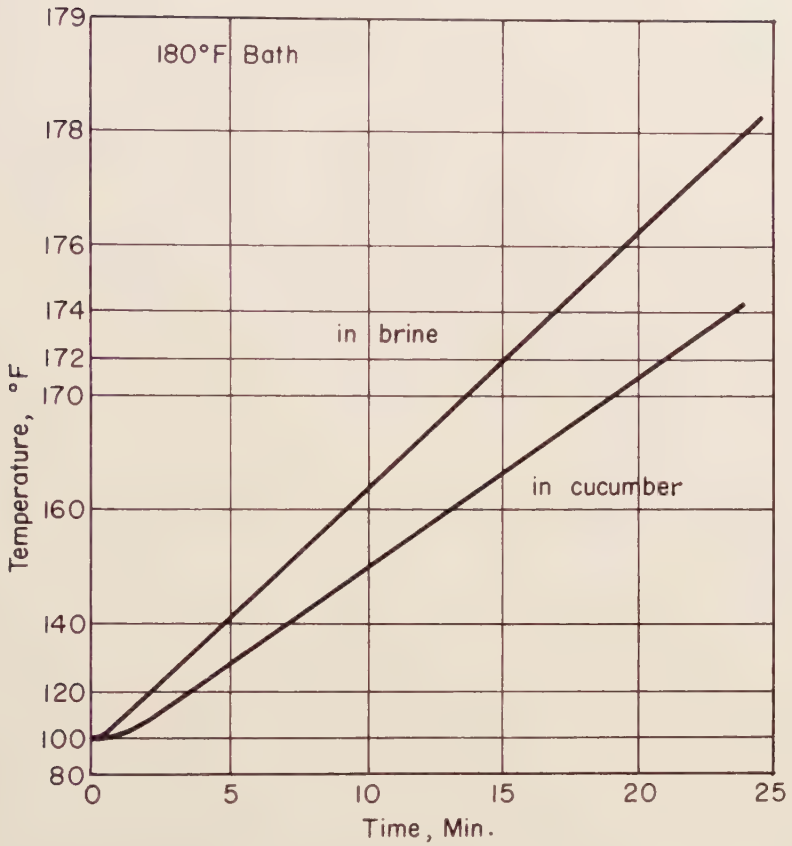

Fig. 1. Temperatures in jars of whole pickles in the vicinity of the point of slowest heating.

between readings made inside and outside a pickle, then the resulting measured temperatures will have an average higher than the pickle temperature, but lower than the brine temperature; moreover, these data will have a larger spread than temperatures measured in brine only or in pickles only.

Table 4 gives the heating characteristics of presumably identical groups of jars packed in the plant at two different times on the same day. The data show a highly significant increase in the heating rate (f_h), although not in lag factor (j), for the jars taken off the line at 11:00 a.m. compared to those at 9:00 a.m. Since both packs were taken from the same packing line, and no effort was made to weigh the product, is it not known if there was a difference in fill ratio. It is known that

TABLE 4—Heating characteristics of whole No. 1 cucumbers in brine at two different times, (line packs, 16-oz. cylinder, 1956)

Time	No. jars in test	Lag factor (j)				Heating rate (f_h) min.			
		Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
9:00 a.m.(*a*) .	16	1.22	1.06	1.45	0.14	17.0	13.6	20.3	1.59
11:00 a.m.....	12	1.19	0.98	1.41	0.15	19.4	17.1	21.8	1.73

(*a*) Same data as Table 2, line 1.

individual packers vary in packing rate from day to day and from one time of day to another.

Conceivably, differential packing rates are achieved at the expense of packing ratio, and the jars in the 11:00 a.m. test were, on the average, more tightly packed, a condition which is believed to cause the product to heat more slowly, (f_h is larger). If such a condition exists, then an additional burden is placed on the processor who does not control the fill ratio closely. This possible variation in fill ratio must be compensated for by longer processing times (with correspondingly lower pasteurizer output), or else spoilage fractions will be higher than usual.

The results of tests on whole No. 2 cucumbers performed in 1956, 1957, and 1958 are given in Table 5. The 1957 and 1958 tests were both made in the laboratory at the same 0.66 fill ratio and there was no significant difference in the heating characteristics. The 1956 jars were line packed and were probably closer to a 20-oz., or 0.62 fill ratio; they exhibited a significantly faster heating rate.

The 1957 results in Table 5 are combined results of a test of the effect of acid strengths of 1.15 percent and 1.4 percent on the heating characteristics. No significant difference was found between the heating rates or lag factors; therefore, the results from the two 7-jar groups were combined.

TABLE 5—Heating characteristics of whole No. 2 brine packed cucumbers, (32-oz. regular jars)

Year	No. jars in test	Fill ratio	Lag factor (j)				Heating rate (f_h) min.			
			Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
1956...	20	LP	1.06	0.85	1.39	0.12	20.9	13.8	28.4	4.24
1957...	(*a*)14	0.66	1.21	0.81	1.51	0.25	27.8	20.4	31.0	2.82
1958...	(*b*)13	0.66	1.25	0.93	1.43	0.16	25.0	21.2	28.9	2.39

(*a*) Seven jars each at two acid strengths 1.4% and 1.15% acid; results combined.
(*b*) Three bath temperatures (160, 180, 200°F); results combined.

The 1958 test (Table 5) was a test in which, for reasons other than determining heating rates, the jars were processed at three different temperatures, 160, 180, and 200°F. No significant difference was found in heating rates or lag factors among the three different temperatures. However, if the two broken heating curves (one at 160°F and one at 180°F) are eliminated from the analysis, then the analysis shows the heating rate at 200°F to be significantly faster than at the two lower temperatures. This trend is in agreement with previous findings for spear products (7). The data shown in Table 6 lend support to this finding of a variation in heating rate with bath temperature (6).

TABLE 6—Heating characteristics of whole cucumbers in brine at three bath temperatures (fill ratio 0.66, 32-oz. regular, thermocouple location 0.5.-in. from bottom, 1959)

Bath temperature, °F	No. jars in test	Mean lag factor, (j)	Mean heating rate, (f_h) min.
180	5	0.81	22.1
195	5	0.93	20.4
211	5	0.92	18.5

An analysis of variance of these data shows a significant difference among the heating rates, but not among lag factors. The data in Table 6 are for a fill ratio of 0.66, the same ratio as the 1957 and 1958 data in Table 5, but the thermocouples were located at 0.5-in. from the bottom, closer to the bottom than was the case for the Table 5 data.

Table 7 gives the heating characteristics of whole No. 2 cucumbers packed in brine in ½-gallon and gallon jars.

Table 8 is a summary of data obtained over the 3-year period 1956-1958. (Data are taken from Tables 1 through 5). Although

TABLE 7—Heating characteristics of whole No. 2 cucumbers packed in brine (fill ratio 0.62, 1957)

Jar	No. jars in test	Lag factor (j)				Heating rate (f_h) min.			
		Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
½ gallon.....	8	1.10	0.93	1.36	0.16	33.7	30.8	37.6	2.48
Gallon.....	4	1.19	0.99	1.32	0.14	38.2	37.0	39.6	1.14

TABLE 8—Average heating rates and lag factors for whole cucumbers packed in brine

Jar type	No. of jars	Fill ratio	Average lag factor (j)	Average heating rate, (f_h) min.
16-oz. cyl...	16	LP	1.22	17.0
16-oz. cyl...	12	LP	1.19	19.4
16-oz. cyl...	8	LP	1.13	17.5
16-oz. veg...	6	0.62	1.14	17.6
32-oz. reg...	20	LP	1.06	20.9
32-oz. reg...	14	0.66	1.01	27.8
32-oz. reg...	13	0.66	1.25	25.0
½ gallon....	8	0.62	1.10	33.7
Gallon.....	4	0.62	1.19	38.2

whole products have been discussed in many published articles, almost all the work has been done on quart jars of pickles.

As a first approach to the understanding of the heating characteristics of whole pickles, consider Fig. 2 in which are plotted all the average heating rates, except that for sweet gherkins, as a function of jar volume. No attempt was made to differentiate between cucumber sizes, different jar geometries for the same jar volume, different brine acidity or different fill ratios.

The dependence of heating rate on jar size is clearly non-linear so that in designing a process for a half-gallon pack, for instance, it is not necessary to double the heating time previously used for a similar quart pack. No obvious relationship is exhibited between the lag factor (j) and jar volume; therefore, an average lag factor can be used for all jar sizes with reasonable accuracy.

For a first approximation of the heating-rate dependence law, one may consider that the more surface available for heat transfer, the faster the jar will heat and that the more liquid to be heated, the longer the heating period. Figure 3 is a plot of the heating rates as a function of surface-to-volume ratio. This curve gives an approximation of the expected heating rate in any other size container in the range studied. There are significant departures from this suggested heating rate dependence that cannot be explained except by a more detailed knowledge of the factors that determine the rate of heating of particulate food products.

The data in Fig. 3 were compared with the results reported by Esselen and Anderson (3). Heating rates, f_h, and lag factors, j, were approximately the same; however, the "whole fresh dill pickle" heating data reported by Esselen and Anderson did not show as much jar-size effect as found in the present study, but the "whole genuine dill pickle" results were nearly the same. Differences between fill ratio, thermocouple position, and other variables could account for the differences in heating rates between studies.

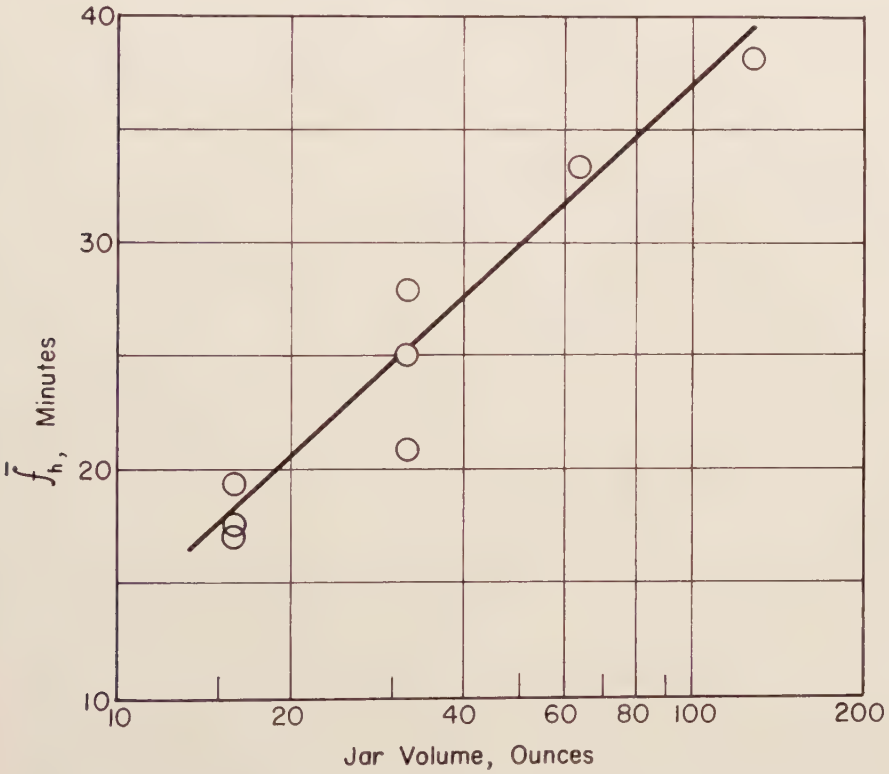

Fig. 2. Heating rate as a function of jar volume.

The variation in heating rate with jar size for convection heating products has been treated theoretically by Schultz and Olson (8); however, the data of the present study do not fit their predictions (based on a jar parameter including diameter and height) as well as the surface-to-volume plot of Fig. 3. A further discussion of this problem is beyond the scope of this report.

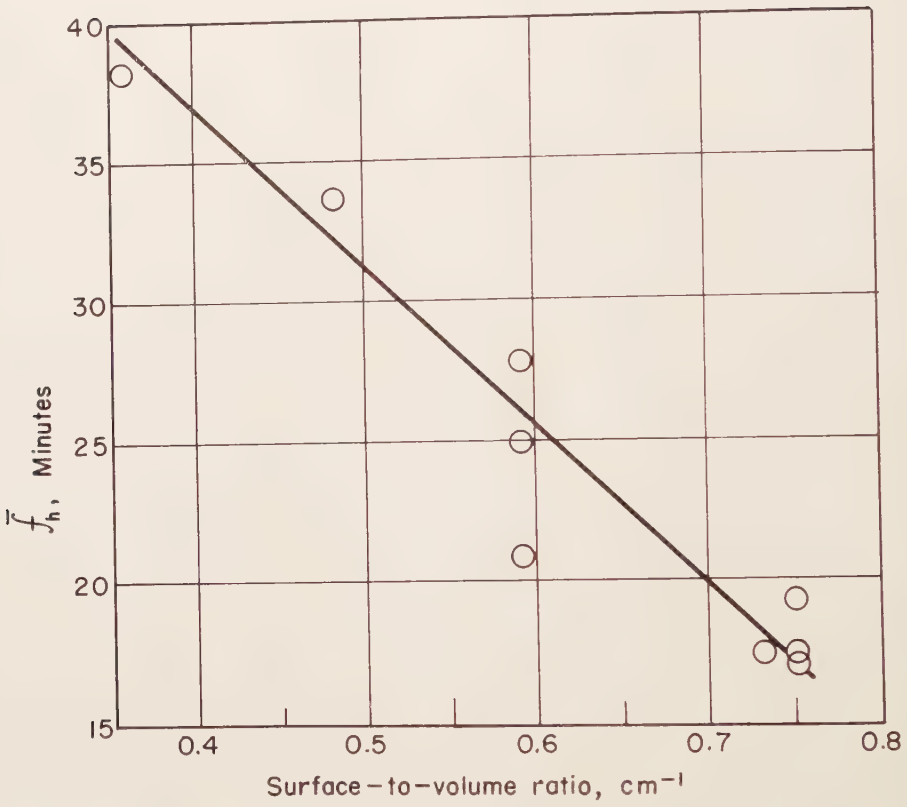

Fig. 3. Heating rate as a function of jar geometry.

SUMMARY

The findings from 3 years' study of heating rates of fresh, whole cucumber pickles can be stated as follows:

1. A curve is given from which an approximation to the heating rate of any particular jar size can be made by knowing the surface-to-volume ratio of the jar.

2. No significant difference was found in the heating characteristics of sweet gherkins and midget dills packed in 16-oz. jars.

3. Differences between liquor temperature and internal cucumber temperature are shown for No. 1 cucumbers packed in 16-oz. jars.

4. Differences in fill ratio are suggested as a source of differences in heating rate for otherwise identical packs; tighter packs appear to heat more slowly.

5. No significant difference in heating characteristics was found between two acid strengths of 1.4 percent and 1.15 percent.

6. A significant difference in heating characteristics was found for quart jars processed at temperatures in the range 180°F to 211°F.

Results 2 and 4 for whole cucumbers should be contrasted with results of similar tests for spear products (7). If a syrup is used instead of brine for a spear product, there will be a marked increase in heating rate (f_h), probably attributable to the fact that in a cut cucumber water leaving the cucumber induces stratification, whereas in a whole pickle this process does not occur to the same extent. Tighter packs in the case of spears have been found to decrease the heating rate slightly, rather than to increase it as is probably the case for whole cucumbers.

Acknowledgments

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SOIL FUNGICIDES FOR POTATO SCAB CONTROL

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Common scab of white potatoes, caused by the filamentous bacterium, *Streptomyces scabies* (Thaxt.) Waksman and Henrici, is a soil borne disease of considerable economic importance to the Michigan potato industry. Losses from scab are due directly to reduction of market quality resulting from the disfigurement of the tuber and to yield reduction where infection is severe. Planting resistant varieties has been the most satisfactory method for avoiding severe losses from this disease. Certain cultural practices, such as rotation, acidifying the soil, avoiding heavy applications of manure, and maintaining adequate soil moisture have also been beneficial.

An effective chemical soil treatment would permit the planting of potato varieties which can not now be grown because of their marked susceptibility to scab. Pentachloronitrobenzene (PCNB) has been used in Michigan (8) and elsewhere (1, 2, 3, 4, 5, 6, 7, 9, and 10) for control of potato scab. Urea-formaldehyde (UF-85) has also been demonstrated to be effective in Wisconsin (1) and in Michigan (8). This paper presents additional data on the effectiveness of these and other fungicides in controlling potato scab in mineral soil.

MATERIALS AND METHODS

Rates of chemical application are indicated in units per area of the total plot. Actually, in band treatments, rates in the treated areas were proportionally higher. Tubers were classified as those with less than 5 percent of the surface scabbed and tubers with over 5 percent

[1]The authors wish to acknowledge the assistance and cooperation given by Vince, Jack, and Robert Hansen, potato growers, Greenville, Michigan; Victor Beal and Clayton Reed, director and county agent, respectively, Cooperative Extension Service, Montcalm County, Michigan; Emerson Jones, agricultural engineer, and Peter Griffin, agronomist, Nitrogen Division, Allied Chemical Company; Dr. Hugh C. Palmer, plant pathologist, Hercules Powder Company; and Earl C. Liston, president, Howry-Berg Steel and Iron Works, Inc., Englewood, Colorado.

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of the surface scabbed. The former was not identical with but approximated a U. S. No. 1 grade.

1959 Experimental plots located in Montcalm County on a sandy clay loam (pH approximately 6.9) with a history of severe scab were planted to the susceptible, Chippewa, variety. One month before planting, plots were manured and heavily limed to encourage a high incidence of scab. Plots (Table 1) were two rows wide, spaced 34 in. apart, 70 ft. long, and replicated three times.

TABLE 1—Influence of urea-formaldehyde (UF-85) and pentachloronitrobenzene (PCNB) on total yield, scab incidence, and marketable production of the Chippewa variety, 1959

Treatment	Rate per acre	YIELD		Tubers with less than 5% surface scabbed(*a*)	Yield of U.S. No. 1 tubers(*a*)
		Tubers over 1⅞"	Tubers under 1⅞"		
		(CWT/A)	(CWT/A)	(Percent)	(CWT/A)
No treatment	.....	104	11	8	7.7
UF-85, 18" band before furrow opened(*b*)	75 gal.	137	20	52	71.4
UF-85, 12" band before furrow opened	60 gal.	136	16	40	54.4
UF-85, 18" band in the furrow	75 gal.	133	14	25	33.3
UF-85, 18" band as furrow was closed	75 gal.	130	13	55	72.5
UF-85, 12" band as furrow was closed	60 gal.	127	15	35	44.9
PCNB, 18" band before furrow opened(*c*)	50 lbs.	114	16	81	93.1
L.S.D. 0.05	.....	26	5	29	29.2
0.01	.....	37	7	40	42.4

(*a*) Tubers approximating a U.S. No. 1 grade either free of scab or with less than 5% of the surface area scabbed.

(*b*) Urea-formaldehyde (UF-85, Allied Chemical Company, Nitrogen Division, Uracide) which contains 85% formaldehyde and 15% urea. UF-85 diluted 1 to 4 with water and applied over the row with a low pressure sprayer mounted on the planter and operated from the power take-off of the tractor.

(*c*) Pentachloronitrobenzene (PCNB, Olin Mathieson Corporation, Terraclor) applied at the rate of 50 lbs. active PCNB per acre.

Urea-formaldehyde liquid was diluted with water in a ratio of 1-4. It was applied in bands over rows with a low-pressure sprayer mounted on the planter and operated from the power take-off of the tractor (Fig. 1. A). When UF-85 was applied before opening the furrow, the sprayer nozzle was directed on the soil in front of the opening disks of the planter. Applications in the furrow were made between the opening disks and the planter shoe. When application was made while the furrow was being closed, spray was directed just ahead of the closing disks.

Pentachloronitrobenzene (PCNB) dust was applied in 18-inch wide bands with a Howry-Berg All-Chem applicator (Fig. 1.B) which was mounted on the tool bar of a tractor equipped with a three-point

Fig. 1. (A.) Planter equipped with a low pressure sprayer for application of liquid urea-formaldehyde. (B.) Howry-Berg All-Chem applicator for applying PCNB dust.

hitch. PCNB applied at the rate of 50 lbs. of active chemical per acre was thoroughly mixed with the soil to a depth of 4 - 6 in. by a series of toothed wheels behind the applicator. In all cases, treatment was applied during the planting operation but before the opening of the furrow by the planter.

1960 Experimental plots were located in Montcalm County on McBride sandy loam soil, pH 6.4. Plots (Table 2) were two rows

TABLE 2—Influence of urea-formaldehyde (UF-85) on total yield, scab incidence, and marketable production of the Sebago variety, 1960

Treatment	Rate per acre	YIELD		Tubers with less than 5% surface scabbed(*a*)	Yield of U.S. No. 1(*a*) tubers
		Tubers over 1⅞"	Tubers under 1⅞"		
		(CWT/A)	(CWT/A)	(Percent)	(CWT/A)
No treatment.....	.....	260	15	27	70
UF-85(*b*).....	40 gal.	282	15	69	195
UF-85.....	60 gal.	266	12	53	141
L.S.D. 0.05		N.S.	N.S.	18	58
0.01				25	67

(*a*) Tubers approximating a U.S. No. 1 grade.
(*b*) UF-85 applied as described in Table 1 in a 12" band over the row as the planting furrow was opened.

wide spaced 34 in. apart, 80 rods long, and replicated three times. Plots (Table 3) were two rows wide, spaced 34 in. apart, 60 ft. long, and replicated three times.

TABLE 3—Influence of urea-formaldehyde (UF-85), and experimental compounds HP-3944, and DAC-649 on total yield, scab incidence, and marketable production of the Chippewa variety, 1960

Treatment	Rate per acre	YIELD		Tubers with less than 5% surface scabbed(*a*)	Yield of U.S. No. 1(*a*) tubers
		Tubers over 1⅞"	Tubers under 1⅞"		
		(CWT/A)	(CWT/A)	(Percent)	(CWT/A)
No treatment.....	.....	179	31	0	0
UF-85(*b*).....	20 gal.	256	26	8	21
UF-85.....	40 gal.	211	15	19	40
UF-85.....	60 gal.	218	12	54	118
HP-3944(*c*).....	30 lbs.	262	26	41	107
DAC-649(*d*).....	60 lbs.	288	17	49	141
L.S.D. 0.05		30	5	17	20
0.01		39	6	24	26

(*a*) Tubers approximating a U.S. No. 1 grade.
(*b*) UF-85 applied as in Table 2.
(*c*) HP-3944 (5-chloro-4-phenyl-1,2-dithiol-3-one, Hercules Powder Company 3944 10% dust). Active fungicide at indicated rate premixed in a ratio of 1 to 4 with dry soil and applied in an 18" band with a fertilizer spreader over the row immediately before planting. Thorough mixing of chemicals to a depth of 4 to 6 inches was accomplished with a Howard Rotovator.
(*d*) DAC-649 (3,3,4,4-tetrachlorotetrahydrolthiophene-1-1-dioxide, Diamond Alkali Company 649 50% WP) applied as HP-3944.

EXPERIMENTAL RESULTS

In 1959 (Table 1), yields of U. S. No. 1 size tubers were generally low due primarily to drought in the experimental area. Had irrigation equipment been available, yields would probably have been higher and the possibility also exists that yields might have been increased still further by the additional nitrogen effect from the urea in UF-85. There was no clear cut evidence as shown by increased dark color of the foliage that urea from this source was generally available to the plants. Yields were increased significantly at the 5 percent level in 4 of the 5 treatments with UF-85. No yield increases significant at the 1 percent level were obtained.

Scab, severe on the untreated controls, was appreciably reduced by all fungicide treatments (Fig. 2-A, B and C). Greatest control was obtained with PCNB applied in an 18 inch band and mixed with the soil before the furrow was opended (Fig. 2). UF-85 was slightly less effective when applied in 18 inch bands either as the furrow was being closed or applied before the furrow was opened and mixed with the soil by the planter. Application of UF-85 in the furrow or in 12 inch bands was relatively less effective.

The most effective method of applying UF-85 in 1959 was used in the 1960 trials (Table 2). Yields approximated those generally obtained in an average season in the area. There was no significant yield increase attributable to the nitrogen in UF-85. Scab was severe and yields of marketable tubers were increased significantly at the 1 percent level by either treatment of UF-85. Although differences in scab incidence between the two rates of UF-85 were not significant, the lower rate (40 gal. per acre) was somewhat more effective in reducing scab and in increasing yield.

Yields of all treatments (Table 3) were increased significantly (5 percent level) over the control. Highest yields were obtained with DAC-649, with HP-3944, and with the lowest rate of UF-85. Phytotoxicity of UF-85 is suggested by lower yields of the 40 and 60 gallon rates.

Scab was so severe in this field that few tubers from the untreated plots had less than 75 percent of their surface scabbed (Fig. 2-D, E, F and G). Although differences in scab control were not significant between the three most promising treatments, greatest control was obtained with UF-85 at the 60 gallon rate, and only slightly less control with DAC-649 or with HP-3944. UF-85 was not effective in

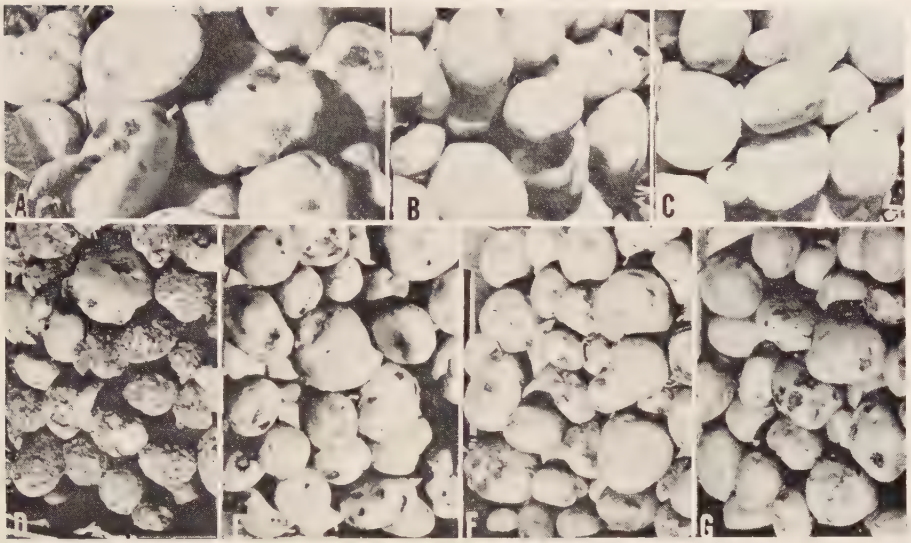

Fig. 2. Tubers from the 1959 plots: A. untreated area; B. UF-85 applied in an 18″ band as the furrow was being closed; and C. PCNB applied in an 18″ band and mixed with the soil before the furrow was opened. Tubers from the 1960 plots: D. untreated area; E. UF-85 60 gal. per acre; F. HP-3944; and G. DAC-649.

controlling scab in this field at the 40- and 20-gallon rates and yields of marketable tubers were very low. Yields of marketable tubers were highest with DAC-649, significantly less at the 5 percent level with UF-85, 60 gal. per acre, and slightly lower with HP-3944.

DISCUSSION AND SUMMARY

Soil fungicides suitable for controlling localized soil borne diseases such as potato scab are available and it is probable that more effective ones may be developed.

Suitable equipment for incorporating materials into the soil is greatly needed and until such equipment is available the use of soil fungicides will be delayed.

PCNB and UF-85 are of considerable potential use in potato production. Experimental compound DAC-649 in one preliminary trial was superior to UF-85. Experimental compound HP-3944, although least effective of those tested, may not have been used at the proper rate for optimum performance.

Chemical control of potato scab will depend on development of

suitable application equipment as well as effective soil fungicides. At the present time, no such equipment is available but an effort is being made to overcome this difficulty. The authors, with the aid of an interested farm implement manufacturer, hope to develop a slurry type of applicator in time for use in proposed 1961 potato scab control trials.

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RESIDUES IN MILK, BLOOD, AND URINE RESULTING FROM VARIOUS TYPES OF ANTIBIOTIC ADMINISTRATION

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INTRODUCTION

DURING THE PAST 14 YEARS, numerous studies have been conducted to ascertain the effectiveness of antibiotics in mastitis treatments and the quantity of the drug residue that persisted in the milk following treatment. The length of time the residue persisted in the milk, blood or urine also received attention.

The research studies have involved a long list of drugs in varying forms and at different dosage levels. Cows of varying milk yields and body weights have been used.

From these numerous studies, some contradictory results have been reported. It was, therefore, deemed advisable to conduct the three trials to be reported here which involved the use of drugs currently most widely used in Michigan for mastitis treatment.

REVIEW OF LITERATURE

After antibiotic drugs came into use for mastitis treatment, cheesemakers and buttermakers encountered serious problems in their processing because some milk received from patrons contained residues of drugs that inhibited the bacterial activity. Concern in this problem led to the earliest studies of antibiotic residues in milk.

Among the earlier contributions was that by Kastli (15) in 1948. It was followed in 1949 by the work of Katznelson and Hood (16), Krienke (17) and others. In 1950 work was reported by Jackson and Bryan (13), Doan (5), Hansen et al. (10) and Krienke (18). All these workers emphasized that for 3 or 4 days following antibiotic treatment for mastitis, the milk was unsuitable for dairy processing. One

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of the first comprehensive reviews of the literature on the subject was that by Claybaugh and Nelson (4) in 1951.

Thurston (23), of the Food and Drug Administration, issued a regulation in 1951 which stipulated that proper labels on drugs for intramammary infusion must carry the precaution that milk must be withheld from the market for 72 hours following last treatment. Since 1954, Food and Drug Administration workers have conducted surveys over the country, which in some markets have shown serious antibiotic contamination of milk. Welch and others (24), (25) and Jester et al. (14) have reported results of these surveys. Grove (8) has also given a summary of the surveys and has described steps to alleviate the residue problem.

Doan (6) in 1956 was one of the first dairy investigators to express alarm that serious incidents might occur among sensitized persons if they used milk containing an antibiotic residue—especially penicillin. Since that date many workers have renewed their efforts to establish more facts pertaining to the persistence of drugs in milk. A review of recent studies has been made by Brown (2) in 1960.

Goldstein (9) has made one of the most recent reports on the persistence of residues in milk. After infusion of 100,000 units of penicillin in each quarter, he obtained detectable amounts as long as 132 hours. With 150,000 units in each of two quarters, he found some residue for 84 hours; the two untreated quarters showed the residue. With 3 million units injected intramuscularly, he found residues for 84 hours. Hargrove and coworkers (11) emphasized that the duration of the residue was nearly the same whether the dose was 100,000 or 300,000 units. They did report that persistence of residue was 24 to 48 hours longer in low-producing cows than in high producers.

Ormiston et al. (19) was chiefly concerned whether procaine penicillin G infused into one quarter might appear as residue in other quarters. With 10 cows, the drug in aqueous suspension appeared in other quarters of eight of the cows; it persisted for 12 hours. The two cows in which no transfer was noted were infected with mastitis when treated. With the drug in oil suspension, the residue appeared in untreated quarters of only three of 10 cows. Randall et al. (20) earlier had found chlortetracycline in ointment was transferred to untreated quarters and persisted 5 days. They also found that the residues in treated quarters persisted 4 and 5 weeks. A further observation was that oxytetracycline did not persist so long as the chlortetracycline.

Shahani (21), working with a dye admixed with the antibiotic, found that drug residue disappeared more quickly in higher yielding cows. He did not observe any transferrence of residue to untreated quarters but postulated this may have been due to a union of the dye and drug in such manner as to prevent a transfer. Stern (22) infused 100,000 units of crystalline penicillin in 20 cc water in three quarters of each of four cows and repeated the treatment every 24 hours for three such treatments. Results showed some transfer of the drug to untreated quarters.

Recently, Blobel and Burch (1) used *Sarcina lutea* as the test organism in the cylinder-plate procedure which is sensitive to approximately 0.0045 units of penicillin per milliliter of milk. After procaine penicillin G crystalline in aqueous suspension was injected intramuscularly, the penicillin was detected in the milk up to 60 hours after injection. When this same form of penicillin was carried in sesame oil and administered intramuscularly, the antibiotic persisted in the milk at detectable levels for some cows up to 36 hours and for others as long as 132 hours.

EXPERIMENTAL

In the work to be reported here, the objectives, procedures, and results of Trials I and II are reported together. Both trials involved intramammary infusion; Trial II was essentially a replica of Trial I.

Trial III is discussed separately. It involved the use of four drugs injected intramuscularly and of one drug administered intravenously.

OBJECTIVES OF TRIALS I AND II

1. To ascertain the time that residues of four selected antibiotic drugs persist in milk following a single intramammary infusion.

2. To observe the time the residues may persist in the milk from different quarters following different dosage levels in the quarters.

3. To determine whether there may be any transfer of the antibiotic from three infused quarters to an untreated one.

4. To ascertain whether the residue might be detected longer in foremilk of a quarter than in the entire milk obtained from that quarter.

5. To observe any relationship between the levels of residues in the milk and those of the urine or blood.

6. To ascertain if the amount of milk from a quarter might affect the persistence of the residue in the milk.

Antibiotics Used

Four drugs that are commonly used in Michigan for mastitis treatments were used in Trial I and three of them in Trial II. Each drug was infused in the udders of two cows as a single dose. One quarter of each cow served as a control with no treatment and each of the other three quarters received a different dosage level of that one selected drug, a light, medium, and a heavy dose. The quarters were randomized. Table 1 indicates the drugs that were used.

The Cows

Eight Holstein cows of the University herd were used. Two cows constituted a pair to receive each drug. It was desired to use cows that currently were producing moderate amounts of milk. One of the lower producers and a higher producer were assigned to each pair; thus the average yields of the pairs were comparable.

The cows were free of clinical mastitis, so far as could be determined by the strip cup, the California Mastitis Test and by bacteriological examinations of the milk. Table 1 indicates the dosage level for each quarter.

PROCEDURE

Milker Pail. Two special milker pails were furnished by the DeLaval Separator Company (Fig. 1). Each pail enclosed four pie-shaped segments; each segment received the milk from one quarter by a direct hose from the teat cup. With care in assembling the pails, it was possible to insure that milk from one quarter was not intermixed with that from another quarter.

Rinsing Milker Pails. The entire milking machine, including the teat cups, quarter segments and hoses, was rinsed twice in clear water to insure no possible carryover of antibiotic residues from one cow or one sample to the next. Antibiotic assays were run on the rinse water to insure this fact. All rinse samples were negative.

Collection of Samples. The blood, urine and milk were collected at each milking usually by two of the authors and two assistants. The foremilk sample from each quarter was obtained by first cleansing

TABLE 1—The drugs, cows used, dosage in each quarter, and duration of residue in each quarter

Drug	Cow No.	Quarter	Dosage	Duration(*a*) of residue—hrs.
(1) Liquamast	625	RF	none	0
		LF	852 mg	36
		LR	426 mg	36
		RR	2130 mg	36
	596	RF	2130 mg	36
		LF	426 mg	36
		LR	none	0
		RR	852 mg	24
(2) Procaine Penicillin G (aqueous)	624	RF	150,000 units	48
		LF	none	24
		LR	300,000 units	48
		RR	1,200,000 units	60
	612	RF	none	12
		LF	1,200,000 units	72
		LR	300,000 units	48
		RR	150,000 units	48
(3) Longicil	626	RF	1,200,000 units	324
		LF	none	72
		LR	150,000 units	96
		RR	300,000 units	96
	623	RF	300,000 units	156
		LF	1,200,000 units	276
		LR	none	24
		RR	150,000 units	96
(4) Pencillin G (potassium)	606	RF	200,000 units	48
		LF	none	24
		LR	100,000 units	36
		RR	1,000,000 units	60
	619	RF	100,000 units	48
		LF	200,000 units	48
		LR	none	12
		RR	1,000,000 units	48

(*a*) Indicates the last milking the antibiotic was detected in the milk, listed as hours after udder infusion.

(1) Oxytetracycline hydrochloride. Chas. Pfizer & Co., Inc.

(2) Chas. Pfizer & Co., Inc. No. DX 158.

(3) Longicil Fortified; benzathine penicillin G and procaine penicillin G in aqueous suspension (For intramuscular injection only) Fort Dodge Laboratories, Inc.

(4) Pitman-Moore Co.

the teat and then milking directly into a clean sterile vial. The sample for the total milk from each quarter was collected as the milk was poured from each segment of the quarter-milker (Fig. 1).

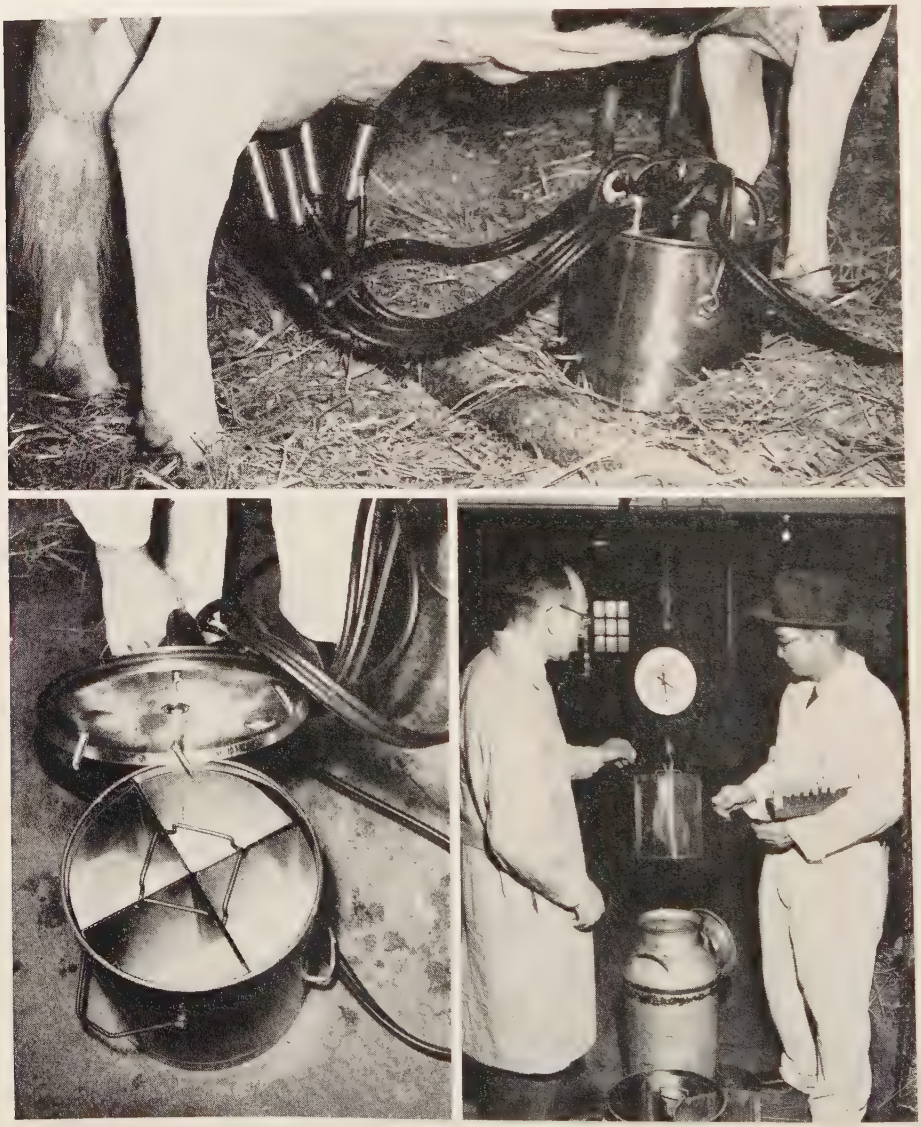

Fig. 1. The DeLaval quarter-milker was used to obtain milk from individual quarters. Top – Quarter milker on cow. Note – milk hose and air hose for each quarter. Left – Quarter-milker pail showing compartments with milk. Note spout in lid for each quarter. Right – Weighing milk from one quarter prior to sampling.

The blood was obtained by tail bleeding, using a clean needle and syringe for each cow at each collection. The blood was allowed to clot and the serum used for assay.

The urine was obtained by inducing natural urination and collecting directly into a clean sterile vial. In a few cases it was necessary to resort to catherization for the urine sample.

Preliminary Milkings. At four milkings prior to the infusions, the cows were milked with the special milker pails. Milk samples were tested; they were all free of antibiotic substances.

Udder Infusion. Udders were infused, following the last preliminary milking. A delay in treatment following this milking was desired in order that some milk might be present in the udder for natural distribution of the antibiotic in the quarter.

Antibiotic Assay. The Standard Disc Procedure, as used by Food and Drug Administration, was used to assay the drug residue in the milk, blood serum, and urine. The test organism was *B. sublitis* ATCC6633 obtained from the Difco Laboratory, Detroit, Michigan. The assays were performed in the Mastitis Laboratory of the Department of Surgery and Medicine.

Note is made of the fact this test is not sensitive to a concentration of less than 0.05 units - 0.05 micrograms per milliliter. Some tests that may be used are far more sensitive. This test was chosen because F.D.A. uses it for screening antibiotics in milk.

Experimental Milkings. The experimental milkings were continued for 168 hours (14 milkings) for the cows infused with three of the drugs. With the Longicil, from which residues persisted in the milk and urine for a much longer period, the milkings were continued for 360 hours (30 milkings). Even at this 30th milking of cow No. 626, some residue persisted in the urine. The urine samples were last collected at 420 hours after treatment when a "trace" was detected.

The footnote (3) to Table 1 indicates that Longicil is intended only for intramuscular injection. It is not for udder infusion, except in the dry cow.

RESULTS

Residues in the Milk. From Table 1 it is observed that after treatment with the Liquamast, there was no transfer of the drug from the treated quarters to the control quarter. With procaine penicillin G

(aqueous) and with penicillin G (potassium), drug residues were detected in the control quarters for 12 to 24 hours. With Longicil, the drug from control quarters was last detected at 72 hours with cow No. 626 and at 24 hours with cow No. 623.

The effect of the dosage level upon the persistence of the drug residue evidently varies with different drugs; however, Liquamast showed no difference (Table 1). Regardless of the dosage of this drug, the residue was detected in all treated quarters for 36 hours, except with the RR quarter of cow No. 596, which was 24 hours. Hargrove et al. (11) reported that the dosage level had little effect on the number of hours residues persisted after infusion.

In Trial I, the Longicil residue persisted much longer from quarters that received the heavy dosage. With the procaine penicillin G and the penicillin G, the heavier dosages, in general, tended to result in drug residues for the longer periods.

The data from this trial are not adequate to indicate whether yield of milk from a quarter affects the persistence of the residue from that quarter. In all cases, the yields were much higher from rear quarters, but the varying dosage levels for the randomized quarters obscured possible effect of yield. It is realized that several workers, notably Hargrove et al. (11), established that cows of low production showed residues in the milk for 24 to 48 hours longer than high producers. Shahani (21) reported the same observations. Jackson and Bryan (13) reported that sodium pencillin G in water gave the highest concentrations of residues when cows were near the end of the lactation. Obviously, milk yields per cow were at the lower levels.

Gradual decline in concentration. In all cases, the decline in concentration of the drug residue was detected in successive milkings. A typical case is that of cow No. 624, which was infused with procaine penicillin G. The data for this cow through 6 milkings are shown in Table 2.

Foremilk vs. total milk. In Trial I, samples of foremilk were taken from each quarter at each milking. Following milking, with the special pail, a sample was taken from the entire volume from each quarter.

The duration of drug residue in the foremilk was essentially the same as in the total volume. In most cases, the milking at which it was last detected in the foremilk coincided with that of the total

Table 2—The decline in residue concentration with successive milkings following intramammary infusion of procaine penicillin G-cow No. 624

Time after infusion, hrs.	Units of penicillin infused in each quarter			
	RF 150,000	LF none	LR 300,000	RR 1,200,000
	Units of penicillin in the milk			
	RF	LF	LR	RR
12	380	2.2	>400	>400
24	190	1.5	70	>200
36	13	0	30	35
48	1	0	0.8	3.5
60	0	0	0	0.9
72	0	0	0	0

volume. In some cases, it persisted 12 hours longer in the foremilk. In fewer cases, it persisted longer in the total volume. Three of the drugs showed quite uniform results; Longicil did not. A typical case of the three drugs is that of cow No. 606, which was infused with the pencillin G. These data through six milkings are shown in Table 3.

The observations which showed this close relationship in the persistence of the drug residues in the foremilk and in the total volume led to a decision to omit samples of foremilk in conducting Trial II.

TABLE 3—The similarity of the antibiotic residue in the foremilk (fore) and in the total milk from each quarter (tot) following intrammary infusion of penicillin G—cow No. 606

Time after infusion, hrs.	Units of penicillin infused into each quarter							
	RF 200,000		LF none		LR 100,000		RR 1,000,000	
	Units of penicillin in foremilk and total milk							
	RF		LF		LR		RR	
	Fore	Tot.	Fore	Tot.	Fore	Tot.	Fore	Tot.
12	>400	>400	0	0.9	>400	>400	>400	>400
24	50	140	0	0.9	>10	70	180	128
36	>10	3.5	0	0	4.7	1.5	7.2	2.8
48	1.9	0.7	0	0	0.8	0	0.8	1.0
60	0	0	0	0	0	0	0.5	0.8
72	0	0	0	0	0	0	0	0

Urine. The persistence of drug residue in the urine varied somewhat with the different drugs. With the penicillin G for both cows, the residue in the urine was detected for only 24 hours; in the milk from treated quarters of these cows, it persisted for 36 to 60 hours. Similarly, with procaine pencillin G, the residue in the urine persisted for 36 to 48 hours, which was a somewhat shorter period than in the milk from quarters that received the heaviest dosages. On the other hand, with the Liquamast, in both cows the residue in the urine persisted for 48 hours; in the milk it was no longer than 36 hours.

Throughout Trial I, the behavior of the Longicil varied from that of the other drugs. The irregular behavior was most noted in the persistence of residue both in the milk and urine. With cow No. 626, residue was detected in the urine for 420 hours (35 milkings) after treatment. This was 96 hours longer than in the milk from the quarter which received the heaviest dosage. The other, cow No. 623, showed comparable results.

Blood serum. In only two of the cows was any drug residue detected in the blood. Cow No. 625 showed a trace at the first milking following the infusion of her quarters with Liquamast. Number 624, infused with procaine penicillin G, showed 0.78 units at the first milking. Even with the Longicil, which so often showed irregular behavior, there was no residue detected in the serum, which by inference was less than 0.05 units per ml. of serum.

Randall et al. (20) and Edwards and Haskins (7) comment on the fact they found higher concentrations of residues in the milk than in the blood. The explanation Randall et al. (20) give is that the mammary gland concentrates the drug in the milk. It would seem that the greater dilution effect, because of a greater volume of blood than of milk, might be a more plausible explanation.

The procedure in Trial I, in nearly all cases, failed to detect drug residue in the serum. It is believed that in many cases there was some residue in the blood, but at a concentration too low to be detected by the assay that was employed. It is assumed that antibiotics in the urine must have been carried by the blood when entrance to the body was by udder infusion.

TRIAL II

Trial II was originally intended as a replica of Trial I. However, before it was started, three changes were adopted. First, the results

obtained with Longicil in Trial I, when it was infused and not injected intramuscularly as prescribed on its label, led to the decision to omit it from Trial II. Only three drugs were used, i. e. Liquamast, procaine pencillin G and pencillin G.

Second, foremilk samples were not collected in Trial II. The third change arose in the necessity to replace one cow, No. 625, that had been used in the previous Trial for the Liquamast. In the preliminary period for Trial II, milk from three of her quarters showed a recurrence of antibiosis. She was replaced by cow No. 627.

Cow No. 625 had been treated 16 days previously as one of the cows in Trial I. After treatment, residues were detected for only 48 hours in her milk from the three treated quarters and in her urine. But sampling was continued for an aditional 60 hours with no drug residue. Then another 7-day period elapsed before the start of the preliminary for Trial II, when a residue reappeared. The amounts detected were slight, only 0.24 units in each of two quarters and 1.4 units in a third. One quarter was free of residue; it was the quarter that received the highest dose (2130 mg.) 16 days before. The quarter that had no treatment previously now showed residue. This observation is in possible agreement with results reported by Hollister et al. (12). They found some antibiotic activity in the blood of cows that had not received any antibiotic therapy for at least 3 weeks.

TRIAL III

Insofar as the intramuscular and intravenous administrations of antibiotic drugs are sometimes used in mastitis treatment, it was deemed advisable to conduct Trial III involving these procedures. Also these drugs are commonly used parenterally for respiratory disorders and would constitute an adulteration if they are secreted into the milk.

Objectives of Trial III

1. To ascertain the time during which residues of four selected antibiotic drugs persist in milk following intramuscular injection and of another drug following intravenous administration.

2. To observe any relationship between the quantities of residue in foremilk and in the total volume of milk.

3. To observe the period of time after treatment when residues might be detected in the blood serum and urine.

Antibiotics Used

Four drugs were used intramuscularly and one intravenously. They are enumerated in Table 4. Each drug was administered to three cows.

TABLE 4—The drugs, dosages and cows used in Trial III (Groups 1 to 4 intramuscular; Group 5 intravenous)

Group	Drug used	Dosage	Cows used	Breed	Body weight (pounds)
1	(*a*) Penicillin G (Potassium)	3,000,000 units	578	Holstein.....	1560
			3063	Swiss.....	1630
			2048	Guernsey	820
2	(*b*) Procaine penicillin G (aqueous)	5,400,000 units	575	Holstein.....	1425
			3008	Swiss.....	1550
			2044	Guernsey....	1100
3	(*c*) Procaine penicillin G (oil)	6,000,000 units	609	Holstein.....	1550
			3047	Swiss	1490
			2043	Guernsey....	1025
4	(*d*) Longicil	6,000,000 units	623	Holstein.....	1175
			3064	Swiss.....	1330
			2018	Guernsey....	1575
5	(*e*) Liquamycin	2500 mg. of Oxytetra-cycline	592	Holstein.....	1400
			3048	Swiss.....	1470
			2024	Guernsey....	1300

(*a*) Pitman-Moore Co. for cows No. 578 and 3063, Upjohn Lab. for cow No. 2048.
(*b*) Crystalline in aqueous suspension; Chas. Pfizer and Co., Inc.
(*c*) Crystalline in sesame oil with 2 percent aluminum monostearate. Chas. Pfizer & Co.,Inc.
(*d*) Longicil Fortified; benzathine penicillin G and procaine penicillin G in aqueous suspension; Fort Dodge.
(e) Oxytetracycline—For parenteral use—Chas. Pfixer & Co., Inc.

Cows Used

As shown in Table 4, a group of three cows was used with each drug. Each group consisted of a Holstein, Brown Swiss and Guernsey from the University herd. The Holsteins produced 50 to 60 pounds of milk daily, the Swiss approximately 40 pounds and the Guernseys 20 pounds. Cows were selected for a group on a basis of body weight, as well as milk yield, it being desired that the average weight of the groups might be similar. This average weight for group 1 was 1337 pounds; group 5 was 1390 pounds; the other three groups were intermediate.

Procedure

The cows were milked in their regular turn in the milking line; regular milker equipment was used. Milking was started at 4:00 a.m. and 4:00 p.m. The milking of that part of the herd which included the experimental cows required approximately an hour.

Preliminary

For two milkings prior to treatment samples of milk, urine and blood were collected from the 15 cows used in the trial. No antibiosis was detected in any of the samples.

The Standard Disc Procedure, as used in Trials I and II, was also used in this trial.

Injections

Following the last preliminary milking, the injections were made as indicated in Table 4. For groups 1 to 4, the injections were made in the region of the rump. For group 5, the drug was administered into the jugular vein.

Experimental Milkings

Following administration of the drugs, samples of foremilk and total milk were collected for only four milkings or 48 hours. By that time, it was definite that no further detectable residues were persisting in the milk.

However, sampling of urine and blood at each milking was continued for much longer periods. The urine and blood continued to show drug residues.

Results of Trial III

Table 5 indicates variation among the five drugs in respect to the presence and persistence of residues in the milk, urine and blood.

Residue in foremilk and total milk. In only one case out of the 15, that of cow No. 2018 in group 4, which received the Longicil, was residue detected in the milk for as long as 36 hours. With two cows in group 3, none was detected even at 12 hours in either the foremilk or total milk. These results are at considerable variance from those by some other workers, notably Goldstein (9), who reported the residue persisted 84 hours following intramuscular injection.

From Table 5, it is observed that the persistence of residues in

TABLE 5—Persistence of drug residues after intramuscular and intravenous treatments. (Drugs are described in footnotes to Table 4)

Group	Drug used	Duration of residue(a)				
		Cow No.	Fore-milk	Total milk	Urine	Blood
			Hrs.	Hrs.	Hrs.	Hrs.
1.....	Penicillin G (potassium)	578	12	12	36	12
		3063	12	12	60	12
		2048	0	12	12	12
2.....	Procaine penicillin G (aqueous)	575	24	24	96	36
		3008	24	12	72	24
		2044	24	12	60	12
3.....	Procaine penicillin G (oil)	609	12	0	384	108
		3047	0	0	300	84
		2043	0	0	420	120
4.....	Longicil	623	12	12	420	48
		3064	12	12	432	84
		2018	36	12	456	72
5.....	Liquamycin	592	12	12	72	24
		3048	12	12	60	24
		2024	12	12	60	12

(a) Indicates the last milking that the antibiotic was dectected in the samples.

foremilk was essentially the same as in the total milk. Although not shown in the table, the concentration of the drug in the foremilk was also essentially the same as in the total milk.

As would be expected, the drugs persisted for a much shorter period following the intramuscular and intravenous treatments than was the case with the intramammary infusions of Trials I and II. Also the concentrations of the residues were much lower.

Urine. The penicillin G for group 1 persisted in the urine for a shorter period than the other drugs. The persistence of the procaine penicillin G (oil) for group 3 up to 420 hours is notable. This drug was carried in sesame oil with 2 percent aluminum monostearate (AMS). The drug, when carried in aqueous suspension as for group 2, persisted no longer than 96 hours.

The Longicil, for group 4, showed residue in the urine of the three cows for 420, 432 and 456 hours.

Blood serum. In no case did the detectable residue from a given drug persist so long in the serum as in the urine. In most cases, the periods were one fifth to one third as long. The penicillin G, among all the drugs, showed the shortest persistency in the blood and the urine. The procaine penicillin G, in sesame oil with the 2 percent AMS, persisted longer in the blood than did the other drugs. In this carrier, the drug persisted four to five times longer than when carried in the aqueous suspension.

Conclusions from Trials I and II Involving Intramammary Infusions

From the data in these trials, the following conclusions seem justified:

1. Except with the use of the Longicil, none of the drugs yielded residues in the milk that were detected beyond 72 hours. In only one of the 24 cases with these three drugs was a residue detected as late as 72 hours. This was from the one quarter of cow No. 612 that received the heavy dosage of 1,200,000 units of procaine penicillin G (aqueous). In two other cases, as shown in Table 1, the drug persisted 60 hours in milk from quarters that received the heaviest dosages.

2. With Longicil, the residue continued to 324 hours in the milk of the quarter of cow No. 626 that received the heaviest dosage. With cow No. 623, it persisted 276 hours from her quarter with the heavy dosage. [Obviously, this drug should not be infused in an udder during lactation.]

3. As might be expected, the milk from that quarter of a cow that received the heavy dosage showed the residue for a longer period than the quarters that received the smaller dosages.

4. Except with the Liquamast, there was transfer of detectable residue into the milk of untreated quarters.

5. With three of the drugs, the residues persisted in foremilk and in the total quantity of milk from the same quarter for essentially the same period. But with the Longicil, residue was detected in foremilk 36 to 48 hours later than in the total volume of milk from a quarter.

6. The persistence of the residue in the urine varied somewhat with the drug that was used. With two of the drugs, penicillin G (potassium) and procaine penicillin G (aqueous), the residue in the

urine persisted a shorter period than in the milk. With Liquamast, it persisted in urine at least 12 hours, or longer than in the milk. With Longicil in one of the cows, residue was detected in the urine for 420 hours, which was 96 hours later than in the milk.

7. In only two cases out of the eight cows was any residue detected in the blood serum.

Conclusions from Trial III Involving Intramuscular and Intravenous Administrations

1. Drug residues in most cases disappear from milk in less than 24 hours following intramuscular or intravenous treatment. With one of the drugs, procaine penicillin G in sesame oil with 2 percent aluminum monostearate, no residue was detected in the milk.

2. Drug residues in foremilk and in total volume of milk are essentially of the same concentration.

3. Two drugs administered, procaine penicillin G in sesame oil with 2 percent AMS and the Longicil, resulted in residues in the urine and blood that continued for extremely long periods.

4. When the procaine penicillin G is carried in aqueous suspension, the residue persisted in the urine for a much shorter period than when carried in the oil.

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SOME FACTORS AFFECTING WEANING WEIGHT AND SCORE OF BEEF CALVES

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FOR A BREEDER TO DECIDE how much emphasis should be put on different traits in his selection program, he must know the heritability of the traits and the relationship between them. This investigation was conducted to obtain estimates of the heritability of weaning weight and weaning score and the phenotypic and genetic relationship between these traits under conditions of this test. Before these estimates were made, the data were adjusted for the effect of the non-genetic factors, age of dam, age of calf and sex of the calf. Estimates of the effect of these non-genetic factors were obtained from these data.

MATERIALS AND METHODS

All the calves used in this study were produced at the Lake City Experiment Station. They were sired by performance tested bulls. The tested bulls were sets of half-brothers (usually four) which were loaned to Michigan State University by registered Hereford and Angus breeders in the midwestern states.

The bulls were fed for approximately 150 days at individual self-feeders. The feed was a ground mixture of ear corn, oats, soybean meal and alfalfa hay. From each set of half-brothers the "best" bull was selected for use at Lake City. "Best" in this test was defined as the bull which had the highest score when rate of gain, feed efficiency and conformation rating were given equal weight in a selection index. Each selected bull was mated with 17 to 19 cows.

The original cows at Lake City were a group of grade Hereford cows used in a pasture experiment. At the start of the cattle breeding project, registered Hereford and Angus cows from the University herd were added. Hereford bulls were used on the Hereford cows

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and Angus bulls on the Angus cows. The heifers used as replacements were selected on the basis of giving equal consideration to weaning weight and score.

The cows were confined to the area around the barns from November until after calving. During the winter months, for the first 6 years, the cows received all the mixed alfalfa and grass hay they would consume. Cull potatoes were added to the ration for about two months prior to calving. For the 1958 and 1959 winters, the hay was restricted to 18 pounds per head per day and supplemented with 1 pound of oats. The resulting calf crop was similar to that of the previous two years. The calf crop weaned was 83 percent the last 2 years and 87 percent the previous 2 years.

The calves were dropped in the barn area from the middle of March to the middle of June. The cattle were turned on pasture from May through October. The calves were weaned, weighed and scored in the middle of October each year. The scoring system used was as follows: good=8, good plus=9, choice minus=10, etc.

The replacement heifers were fed hay and potatoes plus oats during their first winter. The average daily gain was 1 to 1¼ pounds per day.

To obtain estimates of how much of the difference between adjusted weights and scores of calves was genetically controlled, heritability of each of the traits was estimated by measuring how much more paternal half-sibs (steers and heifers by one bull) were like each other than they were like unrelated calves. Thus, heritability is defined as the fraction of the difference between animals' own performance which is passed on to their offspring.

A numerical example of this could be as follows:

In a large herd the average weaning weight of calves one year was 400 pounds. Bull and heifer calves were selected which averaged 450 pounds. The offspring from these selected animals were raised under the same average conditions as the parent generation had been raised. The offspring averaged 425 pounds. Heritability in this herd was .5 since half (25/50) of the difference between the selected parents and the herd average that year was passed on to the offspring.

RESULTS AND DISCUSSION

The data in Table 1 show the average weights and scores of 326 calves sired by 23 different bulls.

TABLE 1—Weaning weight by sire groups of calves raised at Lake City experiment station

Year	Sire	Breed	No. of offspring	Weaning weight	Age	Adjusted weight(*a*)	Adjusted score(*b*)
1953	1	H	14	401	185	411	12.9
	2	H	9	415	174	436	14.1
	3	H	9	390	167	419	11.8
Average....	..	..	11	402	177	420	12.9
1954	5	H	16	352	165	389	13.1
	6	H	14	385	178	404	11.7
	7	H	15	348	164	390	11.8
Average....	..	..	15	361	169	394	12.2
1955	5	H	15	361	187	378	11.7
	9	H	12	355	190	357	10.4
	11	H	14	365	182	387	10.7
Average....	..	..	14	361	186	375	11.0
1956	13	H	18	382	183	396	11.7
	14	H	13	371	180	392	12.0
	15	H	14	437	187	438	10.1
Average....	..	..	15	396	183	408	11.3
1957	17	H	16	408	190	418	10.6
	18	H	17	382	183	398	10.2
	19	H	15	406	183	427	11.9
Average....	..	..	16	398	185	414	10.9
1958	21	H	14	373	183	393	11.3
	22	H	13	396	179	409	11.3
	23	H	15	397	195	400	11.0
Average....	..	..	14	389	186	400	11.2
1953.....	4	A	2	478	230	421	14.0
1954.....	8	A	12	388	191	382	12.2
1955.....	12	A	12	403	199	387	12.2
1956.....	16	A	16	397	189	401	12.1
1957.....	20	A	16	378	185	395	11.8
1958.....	24	A	15	410	203	393	11.8

(*a*) Adjusted to a 180-day-old steer out of a mature cow basis by adding 15 pounds to heifers; adding 50, 15 or 10 pounds to calves out of 2-year, 3-year or 4-year-old dams, respectively and adding or subtracting 1.5 pounds for each day the calf was under or over 180 days old at weaning.

(*b*) Scores used were: Good =8, good plus =9, etc. These were adjusted by adding one unit to score of calves out of 2-year-old dams.

Since both the bulls and the environmental conditions changed from year to year, it was impossible to measure how calves have changed genetically during the past 8 years.

To obtain a measure of the non-genetic effects, least-square estimates of the effect of years, age, age of dam and sex of the calf were made. Since sex of animals cannot be changed by selection, its effect on weaning traits may be thought of as a chance or non-genetic effect. The estimates of these effects were:

1. Steer calves averaged 15 pounds heavier than heifer calves.
2. Calves out of 2-year-old dams averaged 50 pounds lighter than those out of mature cows. Calves out of 3- and 4-year-old cows averaged 15 and 10 pounds lighter, respectively, than those out of mature cows.
3. For each additional day of age, the calves averaged 1.5 pounds heavier.
4. Calves out of 2-year-old dams scored, on the average, 1 unit (or $^1/_3$ of a U.S.D.A. grade) lower than calves out of older cows. None of the other non-genetic effects on score was consistent enough to be measured.

Differences between the Angus and Hereford calves were also calculated. These differences were too small to be significant. The Herefords weighed 4 pounds more, but scored .7 less.

The data on the Hereford calves were adjusted for the non-genetic differences before the remainder of the analysis was made. Angus calves were not included since there was only one Angus bull used each year.

The estimates of heritability were .3 for weaning weight and .7 for weaning score. The estimate of heritability of weaning weight is in line with most estimates from other states while the estimate of score is higher than most other estimates. Shelby et al.[1] estimated heritability to be .23 for weaning weight in Montana cattle and Carter and Kincaid,[2] using Virginia cattle, estimated that heritability of weaning weight and score for heifers and steers combined was .37 and .46, respectively.

If the main differences in the estimates from station to station

[1]Shelby, C. E., R. T. Clark and R. R. Woodward (1955). The heritability of some economic characteristics of beef calves. Jour. Animal Sci. 14: 376.

[2]Carter, R. C. and C. M. Kincaid (1959). Estimates of genetic and phenotypic parameters in beef cattle. II. Heritability estimates from paternal offspring and half-sib resemblances. Jour. Animal Sci. 18: 323.

across the United States were caused by sampling errors, the best estimate to use would be an average of all the estimates. This average is near .2 for weaning weight and .3 for score. Thus, both weaning weight and score should be improved in a herd by culling the light and low scoring calves at weaning. Score should improve more rapidly than weight with equal amount of selection practiced on each trait.

Another big factor which affects weaning weight is the mothering ability of the cow. The estimate of the correlation between the weaning weights of calves out of the same cow but in different years was .5. Thus, cows which have calves that are 50 pounds heavier than average this year should have calves that are about 25 ($.5 \times 50$) pounds heavier than average next year. Mothering ability did not appear to have a measurable effect on weaning score.

The procedure used to measure the relationship between weaning weight and score was to calculate the correlation between these traits. The correlation between the observed weaning weight and score was +.4. However, this correlation does not measure how one trait would be changed by selection for the other trait. There are two possible causes of this correlation. The first possibility is that non-genetic factors, such as amount of feed or number of parasites, made certain calves do extra well and thereby weighed more and scored high while other calves did poorly and thereby weighed less and scored low. If this is the only cause, selection for high scores will not increase weight.

The other possibility is that genes which affect weight also have an effect on score. If this is the case, selecting for score will change the weight of the calves. The relationship between the effect of the genes on weaning weight and their effect on weaning score is defined as the genetic correlation between weight and score. In this herd, the estimate of the genetic relationship between weight and score was negative. That is, where offspring by a sire were above average for score they tended to be below average in weight. The estimate of genetic correlation between weaning weight and score, on an individual basis, was –.44.

Research in other states has been reported showing positive estimates of this correlation. Carter and Kincaid[3] and Koch and Clark[4] estimated the genetic correlation to be +.49 and +.47, respectively.

[3]Carter, R. C. and C. M. Kincaid (1959). Estimates of genetic and phenotypic parameters in beef cattle. III. Genetic and phenotypic correlation among economic characters. Jour. Animal Sci. 18: 331.

[4]Koch, R. M. and R. T. Clark (1955). Genetic and environmental relationships among economic characters in beef cattle. I. Correlation among paternal and maternal half-sibs. Jour. Animal Sci. 14: 775.

One reason the genetic correlation in this study was negative, while it was positive in others, could be that the scoring system used in this herd specified that only the shape of the animal be considered. If size was included as one of the factors in the scoring system, this would automatically contribute a positive genetic correlation between weight and score.

Where two or more traits are being considered when replacement animals are selected for a herd, greatest overall improvement can be made by using a selection index. The selection index which appears most useful for selecting on weaning weight and score is:

Index=weaning weight + 3.7 (weaning score)

Thus, a 400-pound calf with a score of 10 would have an index of 437.

This index was developed using the following factors: Heritability for weight and for score was .2 and .3, respectively. The variance for the two traits was 1,600 and 2.3, respectively. The economic worth of each of the traits was $.30 and $2.70, respectively. The phenotypic and genetic correlation between the traits was .4 and 0, respectively.

If in a particular herd, the numerical values of any of the factors differ markedly from those listed in the preceding paragraph, an index for that particular herd should be calculated. No herd will be large enough to estimate the numerical value of the factors completely free of sampling errors. Therefore, the numerical values of the factors estimated from a particular herd should be reduced back toward the average of the factors found in other herds before the index for the particular herd is calculated. For example, the estimate of genetic correlation between weight and score in this herd was −.44, but the average found in other herds was +.48; therefore, the value of 0 was used for the genetic correlation when the index was calculated.

SUMMARY AND CONCLUSIONS

1. The weaning weights and scores for 326 calves in 23 sire groups were investigated.
2. Adjustment factors to remove the effect of age of dam, sex of calf and age of calf were presented.
3. Heritability estimates for weaning weight and score were .3 and .7, respectively.

4. The phenotypic correlation between the weight and score of the calves was +.4. However, the genetic correlation between these traits was –.44.
5. A selection index to be used in a general herd was proposed— I = weaning weight +3.7 × (weaning score).

POLYETHYLENE COATED PAPER MILK CONTAINER[1]

I. Durability

By T. I. HEDRICK, J. C. BARNES and L. G. HARMON

Department of Food Science

INTRODUCTION

The use of paper milk containers has increased extensively in recent years. Approximately 90 percent of the milk sold in super markets is packaged in paper containers. Most of these are wax coated. Nevertheless, the wax coated milk container has objectional features that are evident during milk packaging and in the consumer's home. A polyethylene coated milk container seemed to offer the possibility of eliminating the undesirable aspects of the wax coated container.

Although a limited amount of milk has been packaged in plastic coated cartons in recent years, information in the literature is meager regarding the durability of these containers during use. Burgess[2] reported that polyethylene, as a paper coating, had water vapor resistance. Other characteristics such as flexibility and folding endurance rated highly, even with aging. The advantages of polyethylene laminated to paper included toughness, tear resistance, extensibility, flexibility at low temperatures, vapor proofness and sealability with heat.[3]

This study was initiated to investigate the durability of the polyethylene coated milk container while handling under competitive commercial conditions during packaging, storage and distribution.

[1]Authors appreciate the valuable assistance of Dr. H. J. Raphael and Mr. James W. Goff of the Packaging Department.

[2]Burgess, L. M. (1950). Uses of polyethylene as a paper coating. Paper Trade Journal 130: (25) 31, 38.

[3]Anonymous (1950). Polythylene on paper. Modern Plastics 28: (4) 67-71.

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EXPERIMENTAL PROCEDURES

Polyethylene coated paper milk containers were received from a commercial supplier in the flat shape and stored at room temperature until used (a few days to 6 months). The containers were produced from 17-point paperboard. The inside had a 1 mil. thick and the outside a ½ mil. thick polyethylene coating on the paperboard.

Midget, Junior or Senior models of experimental Pure-Pak milk packaging machines were used to shape the flat container, form and seal bottoms, fill, crimp and seal the top. The machines had been altered extensively from the wax type machine by eliminating the wax tank and cooling compartment and altering the sealing device to accommodate the polyethylene coated containers.

Next, the full containers were inspected for defects and manually placed in wire or aluminum cases (20 per case) before being conveyed into the cooler. Random samples were taken for durability tests. The remainder was sold on the retail routes or through the Dairy Store and vending machines.

During each day's trial, 200 to 2,500 quarts of pasteurized, homogenized whole milk were packaged. Cultured buttermilk and orange drink were packaged only when needed for the trials.

In the absence of a specific test to measure the ability of paper milk containers to endure handling, several related tests were used which were designed to measure durability of packages.

Bulge Test. The Bulge Test consisted of accurately measuring the outside distance between the two sides, midway from the bottom and the top (not including the gable); the panel with the pouring lip was considered the front of the container. Measurements were taken to the nearest 1 32 inch and the bulge was expressed as a whole number which represented the numerator in 30 seconds of an inch. Containers filled with milk, cultured buttermilk or orange drink were held in storage at 33°, 41° and –15°F. Case storage restricted bulge, so containers were placed on the shelf without contact with each other. Thawing of frozen samples was accomplished by transferring containers to 41°F. storage. Bulge was checked after 7 days at 41°F.

Drop Test. The Drop Test equipment consisted of a metal frame of four angle irons just large enough to permit the quart container to fall freely to the bottom which had four small raised corners. The impact of the contact was confined to the raised corners. The con-

tainer was dropped four times from a height of 7 inches and was given a one-quarter turn after each drop.

Incline-Impact Test. The Incline-Impact Test involved a carriage mounted on a frame with a 10-degree slope. A wire or aluminum case of 20 containers was placed on the carriage and allowed to roll 30 inches to an abrupt stop. This was repeated for contact with both sides and ends of the case.

Combination Test. The Combination Test was devised to accentuate commercial handling conditions. Quart containers were filled with colored water. They were placed in wire or aluminum cases and tested after 0- and 3-day (41°F.) by the following sequence: (1) a pair of containers were lifted 7 inches and released quickly to drop back into the case, (2) the case was dropped 2 inches each of six times, and (3) the case of containers was vibrated on a standard vibrator[4] for 2 minutes at 210 cycles per minute.

Hauling Test. The Hauling Test was performed by hauling the same cases of filled containers on a regular retail delivery truck for 5 hours on each of 3 or 6 successive days.

After completion of each of the tests described above, the containers were examined very carefully for all types of damage; special attention was given to the detection of leaks and slow seepage.

RESULTS AND DISCUSSION

The data in Table 1 illustrate the bulging tendency of the containers filled with milk, cultured buttermilk with 0.75 to 0.80 percent acidity, and orange drink. The average bulge of the quart containers of milk in storage 3 days at 33°F. was 7.2 (less than one-fourth inch), and 9.1 after 14 days. At 41°F. the average bulge was a little more, 7.7 and 11.2 after 3 and 14 days, respectively. The containers filled with buttermilk had an average bulge of 6.0 and 10.3 after 3- and 14- day holds, respectively, at 33°F.; and 6.7 and 10.5 after similar holding times at 41°F. The average bulge of quart containers of orange drink was equal or less than the containers of buttermilk, the values being 6.0 and 7.8 for 3- and 14-day holds at 33°F., and 6.3 and 9.3 for similar holding periods at 41°F.

The freezing of milk, buttermilk or orange drink in the containers and a subsequent 7-day hold at 41°F. did not materially in-

[4]Packaging Tester SNLVMCH 35, type 400, LAB Corporation.

TABLE 1—The rigidity of polyethylene coated quart containers when subjected to various liquids under different conditions of storage

Product	Storage day.	°F.	Bulge of cartons after storage										Wgtd. Av.	Total
			5 to 6(*a*)		7 to 8		9 to 10		11 to 12		13 to 14			
			No.	%	No.	%	No.	%	No.	%	No.	%		No.
Milk	3	33	15	20.0	58	77.3	2	2.7	0	00.0	0	00.0	7.2	75
	14	33	0	00.0	24	32.0	48	64.0	3	4.0	0	00.0	9.1	75
	3	41	9	12.0	58	77.3	8	10.7	0	00.0	0	00.0	7.7	75
	14	41	0	00.0	0	00.0	10	13.3	61	81.3	4	5.3	11.2	75
(frozen)	..	−15	42	56.0	41	54.7	7	9.3	0	00.0	0	00.0	6.8	90
(frozen)	7	41	2	2.4	51	60.7	31	36.9	0	00.0	0	00.0	9.1	84
Buttermilk	3	33	40	88.9	5	11.1	0	00.0	0	00.0	0	00.0	6.0	45
	14	33	0	00.0	8	10.7	51	68.0	5	6.7	1(*b*)	1.3	10.3	75
	3	41	20	44.4	25	55.6	0	00.0	0	00.0	0	00.0	6.7	45
	14	41	0	00.0	6	8.3	29	40.3	37	51.3	0	00.0	10.5	72
(frozen)	..	−15	0	00.0	8	14.0	18	31.6	21	36.8	10	17.5	10.8	57
(frozen)	7	41	0	00.0	0	00.0	8	15.1	37	69.8	8	15.1	11.6	53
Orange drink	3	33	53	88.3	7	11.6	0	00.0	0	00.0	0	00.0	6.0	60
	14	33	12	20.0	30	50.0	17	28.3	1	1.7	0	00.0	7.8	60
	3	41	40	67.7	20	33.3	0	00.0	0	00.0	0	00.0	6.3	60
	14	41	2	3.3	14	23.3	27	45.0	17	28.3	0	00.0	9.3	60
(frozen)	..	−15	2	4.4	43	95.6	0	00.0	0	00.0	0	00.0	7.2	45
(frozen)	7	41	0	00.0	0	00.0	27	60.0	11	24.4	7	15.6	10.0	45

(*a*) A bulge unit was considered as 1/32 inch.
(*b*) Ten cartons also showed 15 to 18 units of bulge.

crease the magnitude of the bulges which were 9.1, 11.6, and 10.0, respectively.

The results show that the polyethylene containers were slightly more susceptible to bulge at the higher temperature and longer holding time. High acid products such as cultured buttermilk caused the containers to bulge a little or no more than low acid products such as milk. However, the inability of the liquids to penetrate the relatively impervious polyethylene prevented serious bulging. Consequently, the bulge of these containers was less than the common wax coated containers under the same trial conditions.

The data on the susceptibility of the polyethylene coated containers to damage as indicated by leakage, including trace seepage of the contents, are given in Table 2. After 3 days of storage at 41°F. cartons of milk were subjected to the Drop Test. Most of the leaks which resulted from the Drop Test were in the bottom of the containers indicating an inferior bottom seal. During the progress of this work the mechanism for making the seal was improved and in

TABLE 2—Leak development in filled containers subjected to various tests

	Polyethylene coated				Wax coated			
Held (days).....	0		3		0		3	
Drop Test (individually)								
Leaks in containers....	3		21		4		5	
Containers with leaks..	3		21		4		5	
Total containers.....	100		100		100		100	
Incline-Impact Test								
Type of case	Wire	Al.	Wire	Al.	Wire	Al.	Wire	Al.
Leaks in containers....	9	8	36	50	33	36	27	44
Containers with leaks..	9	8	23	38	24	30	18	29
Total containers.....	100	100	100	100	100	100	100	100
Combination Test								
Leaks in containers....	109	33	121	59	33	16	24	6
Containers with leaks..	66	22	73	43	28	15	23	6
Total containers.....	100	100	100	100	100	100	100	100

subsequent trials the number of leakers among polethylene coated containers was reduced comparable to the wax coated containers.

The severity of the Incline-Impact Test is indicated by the large number with leakage after the 3-day hold (Table 2). Containers fitted snugly in the aluminum case but loosely in the wire case, and the number of leakers was 23 and 38, respectively, out of 100 tested in each type of case. Most of the damage occurred in the bottom of the containers. A comparable amount of damage occurred in the wax containers but the damage was in the top section of the containers rather than in the base. This test was more rigorous than the agitation to which containers are subjected in normal handling in a dairy plant and during distribution.

The Combination Test (Table 2) was also considered more severe than regular handling of containers especially when the test was performed with containers stored in the wire cases. Both the polyethylene and wax coated containers developed more leakage when tested in wire cases with 0-day hold and also after 3-day hold than in the aluminum cases. All the leakage resulted from damage in the base of the containers. In general, wax coated containers were able to resist damage during the test better than the polyethylene coated containers. Apparently, the thickness of the wax coating had shock absorbing effects.

During a period of 9 months, numerous Hauling Tests were conducted on containers in wire and aluminum cases. Five different lots of containers were represented. After three trips, the percentage of leaking containers varied from 30 to 100. Most were of the very slow seepage type.

Improvement in container production techniques resulted in a decrease. The die used in cutting the containers from the paperboard was directly related to the leakage during the Hauling Test. Imperfections in the die were gradually eliminated. Other factors contributing to the problem of leakage were (a) improper heat and pressure application for sealing, (b) inferior glue or its application on sideseams and (c) moisture migration into the uncoated seam edge of the paperboard inside the container. The final two trials (80 containers) had no leakers after the 3-day Hauling Test.

In general, the four tests, although severe, were useful in locating weakness in the top, bottom and side seam areas of the polyethylene coated container, so corrective measures could be applied. During most of the durability trials, the polyethylene coated container manu-

facturing facilities were in the development stage and thus were improved as defects were noticed. The subsequent packaging of milk in the improved containers under commercial conditions, and distribution which included store, retail and vending, resulted in less than one leaker per 2,000 containers during a 3-week period.

SUMMARY AND CONCLUSIONS

The modified Midget, Junior and Senior models of Pure-Pak machines were used to form, fill and seal polyethylene coated paperboard milk containers for experimental purposes and commercial distribution. Polyethylene coated containers of quart size showed a slight increase of bulge when held at 41°F. compared to 33°F. and at 14 days compared to 3 days of storage. The bulge of containers of milk was slightly less than containers of orange drink and buttermilk in some but not all the trials. Freezing and defrosting the containers and contents did not cause excessive bulging. In fact, the average bulge of polyethylene coated containers was much less than wax coated cartons. Bulge was not a problem under the normal commercial conditions.

The Drop, Incline-Impact, Combination and Hauling Tests were helpful in demonstrating the deficiencies in the production of the polyethylene coated containers during the developmental stages. The principal problem involved leakage and the subsequent improvements in manufacture and sealing of the polyethylene coated container reduced the number of leakers to a percentage that was commercially acceptable.

The durability of the polyethylene coated container for packaging of liquid dairy products was satisfactory for commercial use after the improvements and the polyethylene containers were superior to wax coated containers in some aspects.

POLYETHYLENE COATED PAPER MILK CONTAINER

II. Product Stability and Consumer Acceptance

BY T. I. HEDRICK, J. C. BARNES and L. G. HARMON

DEPARTMENT OF FOOD SCIENCE

INTRODUCTION

A FEW REPORTS in the literature indicate that an off flavor was imparted to milk packaged in some types of plastic surfacing materials such as vinyl. Burgess (2) concluded that polyethylene on paperboard caused less change in food products than other plastic coating materials but did not specifically list the coatings that were compared to polyethylene. Doan and Myers (4) in 1936 reported that milk in paperboard containers developed an oxidized flavor more slowly when exposed to direct sunlight than milk in glass bottles. Other investigators (3) (5) confirmed the observation. The retardation of the rate of flavor change was principally due to the paperboard barrier rather than the surfacing material.

With the improvement of polyethylene as a coating material for milk containers and the improvement of its application to the paperboard, more information was needed to ascertain the effect on organoleptic quality of the milk. The influence on consumer acceptance or preference compared to wax coated paperboard cartons was important. This study was undertaken to investigate these and related factors.

EXPERIMENTAL PROCEDURE

Modified Pure-Pak machines, Midget, Junior and Senior models, were used to form, fill and seal polyethylene coated paperboard containers (quarts) with pasteurized, homogenized whole milk, cultured buttermilk or orange drink. The products and containers were examined by a panel of trained judges after various storage periods at 33° to 60° F. Also, containers of milk were frozen and stored at −15° F. for 15 to 34 weeks. The product was defrosted 4 days at 41° F.

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After thorough mixing, each sample was examined for off flavors induced by the polyethylene coating in contact with the milk. A panel of skilled dairy product judges made the organoleptic inspections.

The effect of direct sunlight on the contents of the polyethylene coated carton was determined by exposure of the quart cartons to sunshine for 1 and 2 hours, after which the cartons were immediately placed in a 41° F. refrigerator for 48 hours. The milk was scored for flavor by dairy product judges.

To ascertain the temperature change of contents of quart polyethylene coated cartons, water was packaged and allowed to stabilize by holding 5 days at 38°, 44°, or 51° F. The cartons were then placed individually on a shelf in a room controlled at 73° F. and 50 percent relative humidity, for a specific time ranging from 55 to 68 minutes. The cartons were inverted six times, and the temperature of the contents was recorded to the nearest 0.5° F.

A total of 464 retail route customers receiving milk in cartons 3 days a week were supplied with approximately one-half of each delivery in polyethylene coated containers of quart capacity and the remainder in wax coated containers. After this procedure had been in effect for 1 month a questionnaire was given to each family. The number responding was unusually high with 89.44 percent of the customers completing and returning the questionnaire.

RESULTS AND DISCUSSION

The results of organoleptic examination of samples (22 trials) conducted over a period of 6 months demonstrated that the polyethylene coating did not cause an off flavor in pasteurized, homogenized whole milk stored for 7 or 14 days at 33° or 41° F. Milk held 4 or 7 days at 50° or 60° F. deteriorated in flavor because of microbiological growth, but this deterioration could not be attributed to contact with the polyethylene coating.

Cultured buttermilk was held 4 and 7 days at both 33° and 41° F. with 420 samples indicating no off flavor from the polyethylene coating. Results of organoleptic examination of 340 samples of orange drink also did not show flavor deterioration from the coating when held 4 and 7 days at 33° or 41° F.

Two hundred samples of milk in 10 trials were held frozen at −15° F., then defrosted and scored for flavor. None had a flavor

change attributable to contact with polyethylene. Samples stored frozen for 26 to 34 weeks developed a slight stale flavor but this was not caused by the polyethylene coating on the inside of the carton.

Polyethylene coated cartons were not effective in the prevention of oxidized flavor induced by direct sunlight. One hour of exposure caused little or no detectable flavor change, but 2 hours of sunshine lowered the organoleptic score 1.5 to 4.0 points in nine trials, with the defect being characteristic of the "sunshine flavor". These results agree with the findings of Doan and Meyers (4) Dahle and Josephson (3) and Prucha and Tracy (5) who reported that wax coated paper milk cartons did not prevent sunshine induced oxidation of milk.

Table 1 shows the increase in temperature of quarts of water packaged in polyethylene coated paperboard when held at 73° F. for approximately 1 hour. The range in holding time was due to the interval required to take the temperature of each of the 20 cartons. In the meantime, the contents were gradually increasing in temperature. The contents of cartons with initial temperatures of 38.5°, 44.0° and 51.5° F. gained an average of 10.90°, 9.50° and 7.70 F., respectively. The increases were slightly higher than the increases in corresponding cartons coated with wax (10.55°, 9.13° and 7.28° F.). These results indicate the insulating qualities of the two containers are similar.

TABLE 1—Average temperature increase of water in a quart polyethylene coated carton

Number of samples	Initial water temp. (degrees F.)	Temp. held (degrees F.)	Time held (minutes)	Range of temp. (degrees F.)	Average temp. gain (degrees F.)
20	51.5	73	55 to 68	6.5 to 9.5	7.7
20	44.0	73	55 to 68	6.5 to 12.5	9.5
20	38.5	73	55 to 68	9.5 to 15.0	10.9

There were 415 questionnaires (89.44 percent) which were completed and returned by retail milk customers who received their milk in both wax and polyethylene coated containers. Table 2 presents a summary of the replies of these customers.

The replies indicated that 93.3 percent of the customers preferred the appearance of the plastic coated container; 6.2 percent had no preference and 0.5 percent favored the wax coated container. A few

TABLE 2—Summary of customers' replies on preference between polyethylene coated and wax coated paperboard milk containers.

Factor	Customers' preference		None	Failed to choose
	Polyethylene	Wax		
Appearance	387	2	26	0
Feel	393	6	16	0
Use on table	353	1	56	5
Storage in refrigerator	369	3	41	2
Ease in opening and closing	364	19	30	2
Pouring	310	28	70	7
Tendency not to bulge	191	150	68	6
Leaking	200	124	76	15
Uses for empty containers	181	5	212	17

of the favorable remarks about the polyethylene container were "brighter in appearance", "cleaner looking" and "sharper". The wax coating tended to dull the print and colored design on the containers. A recent report (1) emphasized the eye appeal of the polyethylene coated containers.

The "feel" of the polyethylene coated milk package was preferred by 94.7 percent and 3.86 percent considered both equal for this factor. Comments by the majority were mainly that the feel was "smoother with no residue".

The polyethylene was preferred by 85.1 percent for handling at the table and by 88.9 percent for storage in the refrigerator. The principal reason given was, "no wax residue" at point of contact.

The wax coated container had a ½-inch overlap at the top. This was eliminated on the polyethylene coated cartons. Customers approved of the sealing without overlap as 87.7 percent favored the polyethylene coated carton for ease of opening. An adverse comment was that the reclosure on the polyethylene carton was less satisfactory. The overlapping of the top was beneficial in respect to reclosing. Although 74.7 percent chose the polyethylene coated container for pouring none gave a reason. Apparently, related factors also influenced the choice of the majority of the customers.

Forty-six percent of the customers indicated that the polyethylene carton showed less tendency to bulge, whereas 36.1 percent favored the wax carton on this factor. Sixteen and four-tenths percent had no preference. The lack of a distinct preference was atttributed to

the relatively short time the full cartons were stored in the home. Previous investigations showed less tendency for the polyethylene coated cartons to bulge during prolonged holding, especially with distinctly acid products such as buttermilk and orange drink.

Of the customers, 48.2 percent expressed an opinion that the polyethylene coated carton would be less likely to leak whereas 30 percent thought the wax coated containers would be more leak-proof. Since the retail driver did not deliver milk in leaking cartons and only a very few developed in the home, the reason for selecting one type over the other apparently is based on opinion rather than actual experience with leakers. Consequently, the "no choice" percentage should have been very high instead of only 18.3 percent.

Preference for the uses for empty containers showed that 43.6 percent favored polyethylene and only 1.2 percent favored wax coated containers while 51.1 percent had no choice and 4.1 percent did not comment. Two of the common remarks of those choosing the empty polyethylene coated cartons were: (1) "safer for the children to play with", (2) "can use for food storage in refrigerator or freezer without wax contamination".

In general, the customer acceptance of the polyethylene coated milk container was very encouraging. Many customers expressed a regret when the trials ended and the polyethylene coated containers were discontinued. Most of the few customers who insisted on a glass bottle rather than the wax coated carton were receptive to receiving their milk supply in polyethylene coated cartons.

SUMMARY AND CONCLUSION

The modified Midget, Junior and Senior models of Pure-Pak machines were used to form, fill and seal polyethylene coated paperboard milk containers for commercial distribution on retail routes. The results of the trials show that the polyethylene coated container did not cause off flavors in milk, cultured buttermilk or orange drink during storage. The same was true after milk was frozen, stored and then defrosted.

Milk in polyethylene coated cartons decreased in flavor score 1.5 to 4.0 points during exposure to direct sunlight for 2 hours. The temperature of water in quart polyethylene coated containers at 38.5°, 44.0° and 51.5° F. increased on the average of 10.9°, 9.5° and 7.7° respectively when held approximately 1 hour at 73° F.

The consumer preference on retail routes was much greater for the polyethylene surfaced cartons than for the wax coated milk containers.

The polyethylene coated milk containers were satisfactory for commercial use and their advantages will cause ready acceptance if competitive in cost.

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PRESERVATION OF MOTILITY IN BULL SPERM AFTER THAWING FROM -79° C.[1]

By M. A. SEVINC[2]

DEPARTMENT OF DAIRY

THE USE OF FROZEN SEMEN for insemination of cattle has one outstanding advantage—the sperm may be stored for years with very little loss of fertilizing capacity (3). In spite of the remarkable possibilities that such an advantage offers, frozen semen is employed exclusively by only a few artificial breeding centers, usually where they experience considerable difficulty in the distribution of semen to the breeding technicians.

Most centers employ frozen semen for special matings only, and these constitute a very small proportion of the cows mated artificially. The chief reason frozen semen is not used to a much larger extent is that it is necessary to use it within minutes after thawing, because its fertility declines extremely rapidly thereafter (2). Insemination of cows immediately after thawing the frozen semen is a costly procedure because it necessitates the transportation of the semen to the farm in the frozen state, requiring specially constructed refrigerators which can operate efficiently with Dry Ice or liquid nitrogen refrigerants. Consequently, at least under many practical circumstances, it would be preferable to distribute thawed semen by routine postal channels, as is currently done with unfrozen semen at most artificial insemination centers. However, success of this proposed procedure is dependent upon the retention of satisfactory fertility in thawed sperm during storage at 5° C. for at least 48 hours.

The present investigation was designed to study the post-thawing survival of sperm when the sperm were frozen more concentrated than necessary to obtain optimum fertility, and then further extended after thawing in one of five commonly used sperm extenders.

[1]This study is being submitted to the Veterinary Faculty, University of Ankara, in a more detailed form.

[2]Current address: Veterinary Faculty, University of Ankara, Ankara Turkey.

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EXPERIMENTAL PROCEDURES

Semen samples were frozen at concentrations of 25 million and 200 million sperm per ml. in a 20 percent yolk-citrate extender (4). In final form, this extender was composed of 20 percent egg yolk, 2.34 percent sodium citrate dihydrate, 7 percent glycerol, and 500 units of pencillin and 500γ of dihydrostretomycin per ml. The method of preparation and the pre-freezing procedure were essentialy those of Foote and Dunn (4). The semen was extended in 38° C. non-glycerol extender and then slowly cooled to 5° C. during a period of 1 hour and 15 minutes. The glycerol extender was then added and the sperm were allowed to equilibrate for about 18 hours, as described by Hafs and Elliott (6). The fully extended semen samples were frozen in hermetically sealed glass ampules by depressing the temperature in an alcohol bath at the rate of 0.8° C. per minute to –15° C., 5° C. per minute from –15° C. to –40° C., and 10° C. per minute from –40° C. to –79°, by the addition of powdered Dry Ice.

After storage at –79° C. for about 24 hours, the ampules of frozen semen were thawed in 5° C. water, with constant stirring to avoid the formation of an ice capsule around an ampule. The semen that had been frozen with 25 million sperm per ml. was transferred to cork stoppered test tubes for storage at 5° C. for 48 hours. Semen that had been frozen with 200 million sperm per ml. was transferred to test tubes and diluted (1:7) to 25 million sperm per ml. with each of five commonly used sperm extenders: an extender identical to that used for freezing the sperm (4) except that it had no glycerol; an extender composed of 50 percent yolk and 1.47 percent sodium citrate described by Bratton and Foote (1); an extender composed of 20 percent yolk, 1.160 percent sodium citrate, 0.168 percent sodium bicarbonate, 0.032 percent potassium chloride, 0.240 percent glucose, 0.240 percent sulfanilamide, 0.750 percent gylcine, and 0.087 percent citric acid described by; Foote, et al (5). (This extender is hereafter referred to as CUE); an extender composed of treated whole milk described by O'Dell and Almquist (7); and an extender composed of treated skim milk described by O'Dell and Almquist (7).

Duplicate test tubes were made for each of these six treatments for each ejaculate of semen, and duplicate motility estimations were made at 0, 8, 24, and 48 hours after thawing by a person unaware of the identity of the semen sample being examined.

RESULTS AND DISCUSSION

Twenty semen samples from 17 bulls were used for the experimental material. The average percentages of motile sperm for each of the six treatments are shown in Table 1 for each of the four storage intervals. In this table it is apparent that, on the average, the sperm frozen at a concentration of 200 million per ml., and then re-extended to 25 million per ml. after thawing, had as good or better motilities than those sperm frozen at a concentration of 25 million per ml. The average of 49 percent motile sperm immediately after thawing the samples frozen at 200 million per ml. and then re-extended in 20 percent yolk citrate to 25 million per ml. was significantly greater than the 44 percent for the samples frozen at 25 million per ml. ($P < .05$). Although the motility of those sperm frozen at 200 million per ml. and then re-extended to 25 million per ml. in 20 percent yolk citrate remained consistently higher during storage, the total decline in the motility of these samples was comparable to that for the sperm frozen at 25 million per ml.

It is also apparent, from the values in Table 1, (See column "decline from 0-48 hours"), that the more concentrated sperm survive significantly better during post-thawing storage when re-extended in either the whole milk or the skim milk extender ($P < .05$). The 52 percent motility for the skim milk extender was the highest average initial motility. Furthermore, this extender resulted in the smallest decline in motility during post-thawing storage at 5° C. for 48 hours. These values for skim milk are strikingly higher than those for the control semen samples, which were frozen with 25 million sperm per ml.

TABLE 1—Average percentages of motile sperm for the six treatments during post-thawing storage at 5° C. for 48 hours

Concentration of sperm at freezing	Extender used for final dilution	Hours stored after thawing					Decline from 0 to 48 hours
		0	8	24	48	Av.	
200	20% yolk citrate	49	44	33	23	37	26
200	50% yolk citrate	40	36	31	24	33	16
200	CUE	51	51	39	30	43	21
200	Whole milk	43	40	34	30	37	13
200	Skim milk	52	46	42	42	45	10
200	Average	47	43	36	30	39	17
25	None	44	42	27	20	33	24

Of the three yolk extenders used for re-extension, the CUE resulted in the best initial and average percentages of motile sperm ($P < .05$), but these values were lower than those obtained for skim milk. However, one may notice that, of the three yolk extenders, the 50 percent yolk citrate resulted in the smallest decline (16 percent in motility during post-thawing storage at 5° C., but even this value is considerably higher than the 13 percent decline for whole milk and the 10 percent for skim milk ($P < .05$).

These results paradoxically indicate that, while the 20 percent yolk citrate may be a good extender in terms of protecting the sperm during the freezing processes, it is apparently inferior in terms of preserving the motile (and presumably fertile) life of the same sperm during post-thawing storage at 5° C. It remains to be shown whether or not one could obtain similar results with regard to fertility. However, we may tentatively conclude that the procedure of freezing semen with a high concentration of sperm in an extender which protects the sperm against adverse conditions during freezing, and then re-extending this semen after thawing in an extender which better promotes survival during storage at 5° C., may eliminate the expensive necessity of transporting frozen semen to the farm. It appears that by thawing the concentrated frozen sperm at the central bull stud and then shipping the re-extended semen to the breeding technicians via routine postal channels, we may expect motility (and presumably fertility) comparable to that obtained by thawing frozen semen at the farm.

SUMMARY

Bull semen frozen in yolk-citrate-glycerol with a concentration of 200 million sperm per ml. and re-extended to 25 million per ml. after thawing survived the freezing process significantly better (49 percent av. motility) than did semen frozen in the same extender with a sperm concentration of 25 million per ml. (44 percent av. motility) ($P < .05$). Survival of the sperm during post-thawing storage at 5° C. was significantly improved when sperm that were frozen concentrated were re-extended after thawing in extenders other than that in which the sperm were frozen.

The results indicate that, although the yolk-citrate-glycerol extender used for freezing is a good extender for protecting the sperm during the freezing process, others are superior in terms of preserving the motile life of bull sperm during storage at 5° C. after thawing.

It is proposed that the procedure of freezing concentrated sperm and re-extending them after thawing in an extender such as CUE or skim milk may eliminate the relatively expensive necessity of transporting frozen semen to the farm. Instead, after re-extension at the central bull stud, the thawed semen could be shipped along routine postal routes.

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THE EVALUATION OF SEVERAL HERBICIDES APPLIED TO TOMATOES AT DIFFERENT TIMES AND LOCATIONS

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Chemical weed control has not been adapted as a commercial practice in tomato production. Chemicals which have given good weed control have frequently injured transplanted tomatoes. The need for a satisfactory herbicide will become more acute if mechanical harvesting and handling are adapted because the processing tomato acreage is likely to increase in order to maintain the necessary tonnage.

REVIEW OF LITERATURE

In recent years a number of chemicals have been tested and judged undesirable for commercial use. Triazines and 2-4-D and its derivatives are toxic to tomatoes (15). Stoddard solvent and trichloroacetic acid (TCA) have shown promise in the past as pre-emergence sprays on direct-seeded tomatoes but were prone to cause injury (9, 13). The results with 1-n-butyl-3-(3, 4-dichlorophenyl)-1-methylurea (neburon) have shown wide variations in crop injury (9, 15, 17). 2-chloro-4, 6 bis (ethylamino)-s-triazine (simazine) (5, 6, 9, 11, 12), Na 2,4-5 trichlorophenoxyethyl sulphate (natrin) (10, 14). 3-(p-chlorophenyl)-1, 1-dimethylurea (monuron), (12), 3-amino-2, 5-dichlorobenzoic acid (amiben) (1, 2, 8, 11), isopropyl N-(3-chlorophenyl) carbamate (CIPC) (8), 4, 6-dinitro o secondary butylphenol (DNBP) (8), alpha chloro N-N-diallylacetamid (CDAA) (9), and the dimethyl ester of tetrachloroterepthalic acid (Dacthal or DAC 893) (11, 16) have usually given good weed control but have also been reported as injuring the sensitive tomato plant. Weed control with 2 chloroallyl diethyldithiocarbamate (CDEC) is inconsistent (5, 6, 7, 11) in the reported literature. Ethyl N, N-di-n-propylthiolcarbamate (EPTC) (7), granular CDAA (8, 16), granular amiben (16), N-(3-chloro-4-

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methylphenyl), -2 methyl-pentamide (Solan) (2, 11, 16) and granular Dacthal (16) have shown promise for pre-emergence weed control in transplanted tomatoes.

MATERIALS AND METHODS

During the 1959 and 1960 growing seasons, six separate experiments were carried out on a Hillsdale sandy loam at East Lansing, and two on a Kalamazoo sandy loam soil at Sodus, Michigan[1] to evaluate several chemicals and rates of application on transplanted and direct-seeded tomatoes. Nine chemicals at varying rates of application were employed. The variety Fireball was used in five experiments, Epoch, Libby's C-52, Heinz 1370 and Fireball in the direct seeded experiment and Fireball and Urbana varieties in another test.

Liquid applications were applied with a small plot sprayer utilizing carbon dioxide as a source of pressure. Chemicals were applied at the rate of 27 gallons per acre with a pressure of 25 p.s.i. Granular materials were applied by shaking the material through a perforated tin can after an experimental small plot distributor proved inaccurate. No attempt was made to direct the spray or granular application away from the plant. The weeds in each plot were weighed in two tests. All areas were cultivated and hand hoed for "lay-by" applications.

Direct-seeded tomatoes were seeded on April 29 in 1960 and treated on May 3 and May 18. Tomatoes were transplanted on May 29 in 1959 and treated on June 1 and 19. Tomatoes were transplanted on May 27, June 2 and 7 in 1960 and treated on June 14, 27 and July 7, respectively.

Temperatures in both years were normal for the area except for August 1959 when the monthly mean was 4° above average. Rainfall for June was 2.2 inches below the long-time average in 1959, 2.8 inches above average in July 1959 and 0.3 inches below average in July 1960. August of 1959 and 1960 were about 1.2 inches above the long-time average of 2.6 inches.

Four chemicals evaluated on direct-seeded tomatoes were Solan, EPTC, CDEC and Dacthal. Nine were evaluated in one or more of the transplanted tests: 1) Solan, 2) EPTC, 3) CDEC, 4) Dacthal, 5) simazine, 6) amiben, 7) zytron, 8) CDAA, 9) neburon.

One experiment was divided to determine injury and weed control in relation to irrigation with ½ acre inch of water immediately after

[1] The assistance of Dr. J. D. Downes was appreciated.

the herbicides were applied. A buffer area separated the irrigated and non-irrigated sections. Analysis of the treatment x irrigation interaction served as the evaluation of herbicidal action.

Granular amiben (4lb A) was applied to 26 tomato varieties during the 1960 growing season. Injury ratings were taken of the two replicates treated in this manner on July 8.

The common weed species present were: lambsquarter (*Chenopodium album*), ragweed (*Ambrosia artemisiifolia*), crabgrass (*Digitaria sanguinalis*), barnyard grass (*Enchinochloa crusgalli*), pigweed (*Amaranthus retroflexus*), purslane (*Portulaca oleracea*). "Stinkgrass" (*Eragrostis cilianensis*) was most prevalent late in the season at the Sodus location.

The weed control rating scale used was: 1.0 no control, 6.0 commercial control, 9.0 weed eradication. The scale of injury rating used was: 1.0 = no injury, 9.0 = killing of plant.

RESULTS AND DISCUSSION

Some of the newer chemicals controlled weeds without injuring tomatoes, while others lacked sufficient selectivity.

Granular amiben gave the best weed control when applied before June 15 in these tests and should be considered as a promising chemical for commercial use.

Pre-emergence applications on direct-seeded tomatoes—Solan gave good weed control and from none to slight injury when applied pre-emergence on the following varieties: Epoch, Libby's C-52, Heinz 1370 and Fireball. No injury was obtained with 2lb/A at either application date (Table 1) but injury did occur at the 4lb/A rate. Solan was tested here during only one growing season and should be evaluated further. CDEC (4lb/A) and Dacthal (8lb/A) failed to provide commercial weed control. EPTC at 4lb/A consistently caused injury.

Pre-emergence on transplanted tomatoes—0-2, 4-dichlorophenyl-0-methyl isopropyl-phosphoroamidothioate (Zytron), emulsifiable amiben, simazine, granular EPTC and granular CDAA (8lb/A) caused sufficient injury at one or more ratings (Tables 2 and 3) to be dropped from further consideration. Applications of Dacthal, CDEC, neburon and EPTC failed to provide commercial weed control at rates which did not injure tomatoes.

TABLE 1—Weed control and injury from four chemicals on direct-seeded tomatoes, 1960

Chemical	Formulation	Rate (lb/A)	Ratings(*a*)			
			Weed control		Injury	
			May 3	May 18	May 3(*b*)	May 18
None.....	..	..	1.0 a	1.0 a	1.0	1.0 a
Solan.....	E	2	3.5 ab	8.0 c	1.0	1.0 a
Solan.....	E	4	7.5 b	8.5 c	6.0	3.5 b
EPTC.....	E	4	7.0 b	7.5 c	5.5	5.5 c
CDEC.....	E	4	3.5 ab	5.0 b	3.0	1.0 a
Dacthal....	WP	8	4.0 ab	4.0 b	2.5	1.0 a
Coefficient of variation (%).....			43	14	44	16

E = Emulsifiable.
WP = Wettable powder.
(*a*) Ratings not containing a common letter are significantly different at the 5% level.
(*b*) Difference between treatments not significant due to unaccountable variation.

Granular amiben provided commercial weed control without injury to transplanted tomatoes. The results shown in Table 3 were obtained when the chemicals were applied to moist soil followed immediately by rain. Injury from the emulsifiable form at both rates was evident 3 hours after application and a month later. The total yield of harvested fruit was reduced by the emulsifiable form (Table 3), but the percentage of number 2 and cull fruit was not increased.

Granular CDAA gave commercial weed control without injury at 4lb/A, but injury was encountered at 8lb/A.

Tomatoes tolerated Solan over a wide range of application rates (2 to 8lb/A) which gave commercial weed control.

A more adequate weed control was obtained with several of the herbicides used by the addition of ½ acre inch of water. No precipitation fell during the 4 days preceding the application of the herbicides or for 5 days after application. Irrigation following the application of granular CDAA (8lb/A) and granular EPTC (6lb/A) did not improve weed control. Irrigation increased the herbicidal action of Solan, granular amiben, granular CDAA (4lb/A), granular simazine and emulsifiable EPTC.

Granular EPTC (6lb/A) gave definite injury with both irrigated and non-irrigated treatments, but injury was more apparent when irrigation water was applied at the time of chemical application.

TABLE 2—The result of herbicide applications on transplants at East Lansing, 1960

Chemical	Formulation	Rate (lb/A)	Ratings(*a*)		Weed weights (lb/plot)(*b*)
			Weed control	Injury	
None	..	...	1.3 a	1.0 a	14.5 b
Dacthal	WP	8.0	1.7 a	1.0 a	20.7 a
CDEC	G	4.0	3.3 b	1.0 a	6.0 c
CDEC	E	4.0	3.7 b	1.0 a	7.8 c
Solan	E	2.0	4.7 cde	1.0 a	4.3 c
Simazine	G	2.5	5.0 cde	1.7 a	4.3 c
Solan	E	4.0	5.0 cde	1.0 a	3.7 c
Simazine	WP	1.0	5.3 cde	2.3 a	3.8 c
Amiben	E	4.0	5.7 cde	2.0 a	3.6 c
Amiben	E	2.0	5.7 cde	1.7 a	5.3 c
Zytron	E	10.0	6.0 de	5.3 b	6.5 c
CDAA	G	4.0	6.3 ef	1.7 a	2.3 c
Amiben	G	2.0	7.0 f	1.7 a	1.6 d
Amiben	G	4.0	8.0 g	2.0 a	2.8 c
Coefficient of variation (%)			37	49	46

E = Emulsifiable.
G = Granular.
WP = Wettable powder.
(*a*) Ratings not containing a common letter are significantly different at the 5% level.
(*b*) Plot area = 100 sq. ft.

TABLE 3—The result of herbicide application on transplants at Sodus, 1960

Chemical	Formulation	Rate (lb/A)	Injury(*a*) (3 hours after application)	Yield (Ton/A)(*a*)
None	..	..	1.3 ab	21.0 cd
Amiben	E	2	6.0 d	17.5 bc
Amiben	G	2	1.8 ab	24.7 d
Amiben	E	4	6.0 d	13.5 a
Amiben	G	4	2.8 bc	21.1 cd
CDEC	E	4	1.0 a	21.0 cd
CDEC	G	4	1.5 ab	23.6 d
CDAA	G	4	1.5 ab	20.0 bcd
Solan	E	2	1.0 a	20.3 cd
Solan	E	4	1.0 a	23.1 d
Simazine	WP	1	1.3 ab	15.7 ab
Simazine	G	2	2.0 bc	18.4 bc
Coefficient of variation (%)			27	14

E = Emulsifiable.
G = Granular.
WP = Wettable powder.
(a) Ratings not containing a common letter are significantly different at the 5% level.

Irrigation did not increase the injury on any of the other treatments.

No visual injury symptoms were observed as the result of the application of 4lb A granular amiben on 26 tomato varieties in 1960.

SUMMARY

Three chemicals provided commercial weed control without injuring tomatoes.

Solan shows promise for use in both direct-seeded and transplanted tomatoes.

The results with granular amiben at 2 and 4 lb A rates in 1959 and 1960 indicate that if FDA clearance is obtained a limited commercial use would seem appropriate to sample environmental conditions, soil types and varieties not covered in these tests and those reported in the literature.

Granular CDAA (4lb A) gave commercial weed control and no injury in these tests.

Emulsifiable amiben, Zytron, simazine, EPTC, Dacthal, CDEC and neburon proved unsatisfactory in these tests as herbicides for tomatoes.

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HEAT TRANSFER THROUGH AN AIR CURTAIN

By GAD HETSRONI[1] and CARL W. HALL

Department of Agricultural Engineering

Frequent opening of the conventional door on a refrigerated storage causes air changes inside cold storages, resulting in refrigeration losses and in increased load on the compressors. Large losses are very costly and frequent opening may prevent the refrigeration unit from reducing the temperature of a new load. It also inhibits maintaining a uniform and constant temperature inside the room.

Williams[2] studied refrigeration losses through the door openings and conveyor passes into cold rooms in a dairy plant. Under normal operating conditions for a 38° F. room, losses through a 42 in. x 78 in. door opening ranged from 722 B.t.u. to 951 B.t.u. per min. By using a diverted air flow technique, they were able to reduce losses from about 950 B.t.u. per min. to 200 B.t.u. per min. With their technique, air from a blower was directed down across the door opening and circulated through a false floor and suction fan.

An air curtain unit consists of a series of nozzles above the entrance which discharge a stream of air downward to an air return grill in the floor. The air is recirculated through ductwork which contains heating and cooling elements, filters and fans. The curtain of air insulates the interior from outside temperature, dust, insects, fumes, etc.

In this study, experimental work was conducted to measure the heat transfer characteristics of an air curtain,[3] installed between a refrigerated room and a warm room, as affected by (1) the air velocity, and (2) the depth of the curtain.

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[1] Hetsroni, Gad (1960). Heat transfer through an air curtain. Thesis for M.S. degree, Mich. State Univ., East Lansing.

[2] Williams, R. M. (1958). Refrigeration losses through open doors and conveyor passes. Unpublished thesis for M.S. degree, Michigan State Univ., East Lansing.

[3] Acknowledgment is made to the American Air Curtain Company, St. Louis, Mo., for supplying an air curtain model used in the study.

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PROCEDURE

An air curtain model was used in the investigation. The air was forced through a distributor formed by six nozzles located over the door opening (Fig. 1). The air was recirculated through a grill in the floor and ductwork. Air movement was provided by four variable-speed fans driven by four 1 15 hp. electric motors. Two fans located above the door opening moved the air downward while the other two fans recirculated the air.

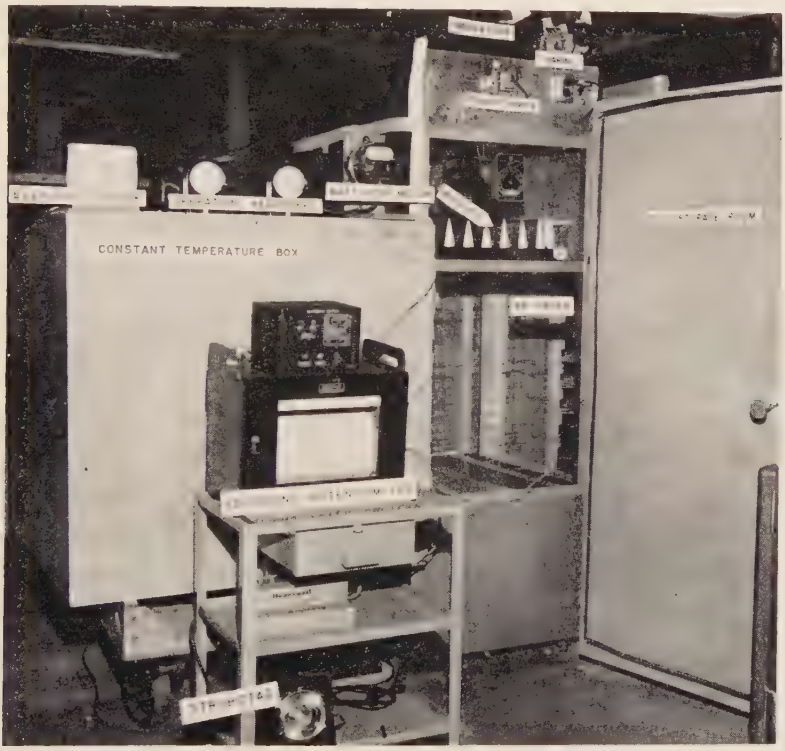

Fig. 1. Experimental set-up used for the investigation. Air moves down through the nozzles to form an air curtain between a cold storage room at 40°F. (right) and the constant temperature box at 85°F. (left).

The air curtain model was placed in a 7.75 sq. ft. opening between two well insulated chambers. One chamber was maintained constantly at 40°F. while the other was maintained at approximately 85°F. by an electric heating mat.

A series of tests on air velocity were first made to obtain the velocity distribution patterns for three depths (variable horizontal cross section) of the air curtain.

The energy used by the electric heating mat to maintain constant temperature, the temperatures in both chambers and at various locations in the air curtain, and the average air velocity and depth of the air curtain were recorded for each test.

Six tests were conducted to determine the heat transfer coefficient of a three-nozzle air curtain, for air velocities ranging from 189 to 646 ft. per min. Four additional tests were run for a six-nozzle curtain for air velocities ranging from 308 to 409 ft. per min.

A series of tests were made to determine the air velocity distribution pattern. The air stream becomes wider as it progresses from the nozzles and the profile of velocity distribution becomes flatter.

The Reynolds number (Re) for each test was calculated using the average values for air velocity and curtain depth, which was at about mid-point between the outlet nozzles and the return grill. The Reynolds number does not change appreciably from the nozzles to the grill, assuming constant air density and viscosity.

The over-all heat transfer coefficient was calculated for each test by the formula:

$$U = \frac{Q}{A\,(t_1 - t_2)}$$

where:

U = over-all heat transfer coefficient, B.t.u. per hr. – sq. ft.°F.
Q = heat quantity transferred through the curtain, B.t.u. per hr.
A = cross sectional area of opening between chambers, 7.75 sq. ft.
t_1 = temperature in the high temperature chamber, °F.
t_2 = temperature in the low temperature chamber, °F.

The over-all heat transfer coefficient was then plotted versus the Reynolds number of the flow (Fig. 2).

RESULTS

To generalize the results obtained in this investigation, a dimensional analysis was carried out.

The dimensionless number that includes most of the units characterizing the flow is the Reynolds number. Another dimensionless ratio

resulting from the analysis was the ratio of the over-all heat transfer coefficient (U) to the equivalent heat transfer coefficient (L) for a certain depth of air stream (D).

This dimensionless ratio was denoted as H and is defined as:

$$H \quad \frac{U}{L} D_0$$

where:

U = the over-all heat transfer coefficient, B.t.u. per hr. sq. ft.°F.

L = the equivalent heat transfer coefficient that includes the effects of conductance and mass transfer which are encountered in the air stream. This coefficient might vary with the Reynolds number of the flow. For the range of $2.5 \times 10^4 < Re < 1.2 \times 10^5$ which was tested, a value of L = 21 B.t.u. per hr. ft. °F., is found by the analysis.

D_0 = the depth of the air curtain when emerging from the nozzles, ft.

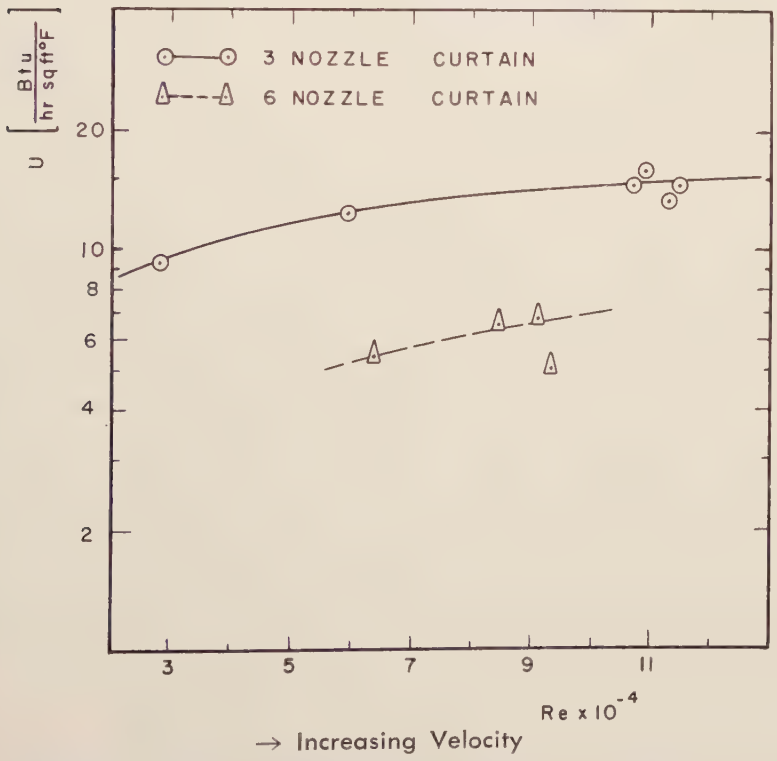

Fig. 2. U-value versus Reynolds number for a three- and six-nozzle air curtain.

The values obtained for H-ratio are summarized in Table 1 and plotted in Fig. 3. The formula that fits this curve best, for the range $Re = 2.5 \times 10^4$ to $Re = 1.2 \times 10^5$ is:

$$H = 0.5 \exp\left(-\frac{1.8}{Re \times 10^{-4}}\right)$$

This formula describes a line asymptotic to $H = 0.5$.

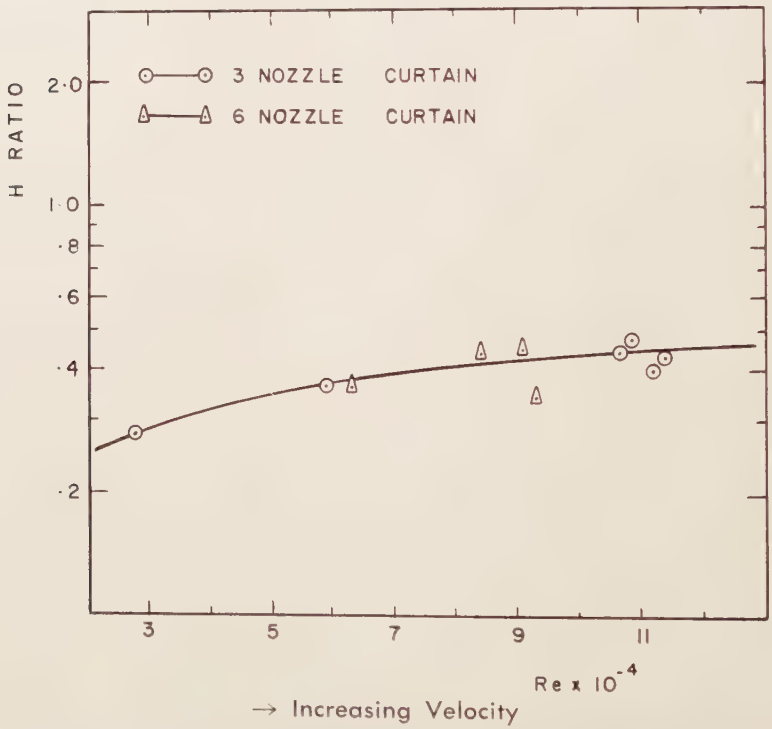

Fig. 3. H-ratio versus Reynolds number for a three- and six-nozzle air curtain.

CONCLUSIONS

1. The air stream becomes wider as it moves away from the nozzles and the profile of velocity distribution becomes flatter. The Reynolds number of the flowing air remains approximately constant.
2. The over-all heat transfer coefficient is proportional to air velocity and inversely proportional to the depth of the curtain for the velocities tested. The values of the over-all heat transfer coeffi-

TABLE 1—Summary of tests of three- and six-nozzle air curtain

No. of nozzles	Fan voltage	Air stream			U	L	H
		D-ft.	V, fpm	Re x 10^{-4}			
3	45	0.97	189	2.80	9.2 ± .20	20.8	.275
3	60	1.14	355	5.92	12.2 ± .67	17.3	.364
3	75	1.31	582	10.68	14.7 ± .48	19.3	.440
3	90	1.17	640	10.91	15.7 ± .20	18.7	.469
3	115	1.14	673	11.41	14.2 ± .63	18.3	.424
3	135	1.20	646	11.23	13.0 ± .24	18.7	.389
6	60	1.56	308	6.37	5.4 ± .36	23.2	.360
6	90	1.53	411	8.43	6.5 ± .46	29.2	.434
6	105	1.81	399	9.12	6.7 ± .57	25.4	.446
6	115	1.81	409	9.33	5.0 ± .11	17.8	.334

cient ranged from 5.0 to 16.0 B.t.u. per hr. - sq. ft. -°F. for a depth of 0.97 to 1.81 ft. and for an average velocity from 189 to 673 f.p.m.

3. The ratio of the over-all heat transfer coefficient to the equivalent heat transfer coefficient (a value of 21 B.t.u. per hr. ft.°F. is suggested) for a certain depth of curtain was found to characterize the heat transfer through an air curtain. This ratio was denoted by H.
4. The H-ratio is related to Reynolds number of the flow by the formula:

$$H = 0.5 \exp\left(-\frac{1.8}{\text{Re} \times 10^{-4}}\right)$$

CONSTRUCTION AND OPERATION OF PNEUMATIC PLASTIC BUILDINGS[1]

By E. A. KAZARIAN and J. D. DOWNES

Departments of Agricultural Engineering and Horticulture

THE NEED FOR A LOW COST, temporary building for farmstead operations can be met with pneumatic plastic buildings. These structures, sometimes referred to as "Bubble Buildings", are constructed by inflating an enclosing membrane and maintaining a small air pressure to support the membrane and any external loads. They can be put up with low initial cost and can be readily taken down and stored or moved. The pneumatic buildings can be used as temporary greenhouses for starting plants or as temporary space for bedding plants or seasonal crops. They may also be used for temporary animal shelters or as temporary storage buildings.

The development of the pneumatic structure is an outgrowth of the radoms developed at the Cornell Aeronautical Laboratory by Walter W. Bird and colleagues. Architect Frank Lloyd Wright demonstrated a full-sized dwelling that could be deflated and hauled away in a station wagon. L. W. McConnell[2] used a pneumatic structure cooled by water mist to encourage the feeding of hogs during hot weather. H. R. Stanton[3] has reported the use of pneumatic buildings in New Jersey for conducting poultry research. The suitability of these structures for temporary greenhouses has been proven in Michigan and Indiana.

Several pneumatic buildings were erected on the Michigan State University campus and at the Horticulture Experimental Farm at Sodus, Michigan. Buildings were erected on campus to evaluate design, construction, operation and maintenance problems. At Sodus, the

[1] Acknowledgment is made to Mr. L. W. McConnell, Agricultural Development Engineer, Indiana & Michigan Electric Company, for his advice and help on this project.

[2] McConnell, L. W. (1957). Pneumatic farm structures experiences and design considerations. Paper 57-611, prepared for presentation at the meeting of the American Society of Agricultural Engineers.

[3] Stanton, H. R. (May 1959). Bubble housing may be in poultryman's future. New Jersey Agr. Exp. Sta. New Jersey Ag. 41:2-3.

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pneumatic buildings were used to cover and protect the vegetable transplants for the experimental farm, and also to study operation and heating costs.

Shapes

Pneumatic buildings can be made into many shapes. The shapes that have been satisfactorily constructed include the hemisphere and a half cylinder with either circular ends or rectangular ends. The building with rectangular ends is made by folding the plastic as shown in Fig. 1. When using a rectangular piece of plastic, the building with the folded ends is very easy to construct.

Fig. 1. A pneumatic polyethylene building showing the rectangular ends made by folding the plastic film.

Enclosing Membrane

The enclosing membrane must have adequate tensile strength, flexibility and puncture resistance over a wide range of temperatures. Many plastic films meet these requirements. Most films are manufactured in widths of 4 to 6 ft. and large sheets have to be fabricated from small pieces of film. This fabrication should be carefully done to assure uniform strength at the joints. Polyethylene plastic film, which is manufactured in widths up to 40 feet, seems to be a good choice of plastic to use for temporary buildings. Clear polyethylene deteriorates under ultraviolet light; therefore, it will not last longer than 1 year unless it is stored away from the sun. More permanent buildings should be constructed of plastic films not subject to ultraviolet deterioration. The thickness of plastic film used in pneumatic

buildings is generally 4 to 10 mils. The 4-mil thickness is strong enough to withstand stresses caused by inflation pressure; however, the film may be susceptible to puncture damage from sharp objects. Where a large amount of mechanical damage can be expected, the 8- or 10-mil thickness should be used. A 6-mil polyethylene film was used to cover the buildings constructed for this study.

Fan and Air Requirements

A small fan could supply sufficient air to support a large, leak-proof structure, but it would be inadequate for initial inflation, and could not provide for rapid recovery in the face of a large temporary demand for pressure. There are many factors which affect the air requirements of pneumatic buildings including leakage around the foundation, opening doors or ports, ventilation, etc. If one fan is required to meet all these requirements, it would have to be a high capacity fan operating over a wide range of air flows. An alternative would be to use two fans—a small capacity fan for maintaining ordinary operating pressures and a large capacity fan for ventilation and for operation when frequent opening and closing of doors is required. The large fan could be controlled by a pressure switch. The heat trapped inside of the clear plastic film building on warm sunny days may cause temperatures too high for best plant growth. Ventilation for temperature control under such conditions may require rates as high as 30 air changes per hour. Temperature build-up may be checked by coating the plastic with whiting as is done with glass greenhouses.

Foundation

Pneumatic buildings exert an upward lift on the foundation. The largest component of the upward lift in these small buildings is due to the inflation or static pressure. Additional lift may be caused by wind pressure on the building. The upward lift per lineal foot of foundation would increase with an increase in the size of building. A common method of anchoring the pneumatic building is to imbed the plastic in a trench and backfill with soil or other suitable material to provide the weight needed to counteract the upward lift.

The foundation must also be adequately sealed to prevent excessive air leakage. Watering the ground surface inside will aid in filling voids in the soil as pressure is applied to the building. Watering the

backfill also helps seal the house as well as settling the soil uniformly around the plastic equalizing tension on the material.

PROCEDURE

A total of five pneumatic buildings were erected for this study. The two buildings erected at Sodus, Michigan in 1958 and 1959 were half cylindrical with circular ends. The 16 by 52-foot buildings were made with 6-mil polyethylene film. The first step in the construction of these buildings was to dig an 18-inch deep trench around the perimeter of the building. The edges of the 32 by 65-foot sheet of film were wrapped around drain tile, placed into the trench and backfilled with soil. In 1960, the building erected at Sodus was made with rectangular ends. This type of pneumatic structure was easier to build. Its construction will be described in detail. The same fan and entrance equipment was used in the construction of all three buildings.

The trench for the rectangular building was dug 12 inches wide and 16 inches deep. The fan and entrance facilities were not dismantled from year to year but left at the building site. The trench, fan and entrances are shown in Fig. 2. After completing the trench, the 32 by 76-foot sheet of 6-mil polyethylene was spread out and centered. The side edges of the polyethylene film were nailed between two 1 by 6-inch boards, Fig. 3. The ends of the film were folded and also nailed between two boards. This procedure was used to keep the edges of the film straight and helped eliminate

Fig. 2. The trench, fan and entrance facilities for the pneumatic building at Sodus.

Fig. 3. Nailing the edges of the polyethylene film between two boards before imbedding in the trench.

wrinkles in the building when it was inflated. The edges of the film were placed in the trench with the boards on the outside wall of the trench. The trench was backfilled with soil as shown in Fig. 4. The backfill was thoroughly wetted to give a good air seal between the plastic and the soil.

Openings were cut in the plastic for the fan and the doorway; the film was fastened to the framework with wood strips. The completed pneumatic building is shown in Fig. 5. The entrance for the pneumatic building consisted of double or "air-lock" doors. Only one door was opened at a time so there would be no appreciable pressure loss from entering or leaving the building. The doors and "air-lock" framework were made of plywood, Fig. 6. A 2 by 2-foot port with a

Fig. 4. Backfilling the trench with soil to anchor the pneumatic building.

Fig. 5. The completed pneumatic building at Sodus.

plywood door was located adjacent to the double doors. A thermostatically controlled motor was used to open and close the port door. The primary purpose of the port was to serve as an outlet for ventilation air; however, it could also be used for passing small materials into and out of the building.

Fig. 6. The double "air-lock" doors and ventilating port for the pneumatic building.

The 16-inch fan powered by a ¾ hp. electric motor was mounted on a platform at the opposite end of the building from the entrance facilities. The air flow into the building was controlled by a simple plywood damper over the fan outlet. The damper was hinged at the

bottom and held against the fan outlet by two adjustable springs. The spring tension on the damper could be adjusted to maintain various pressures inside the building. To maintain normal inflation pressure, the damper would be partially open allowing a small amount of air into the building. When the pressure inside the building would drop, the damper would open wider to allow more air to enter the building.

In 1958, the building at Sodus was heated electrically by installing soil heating cable to provide about 125 watts per square foot of bed area. Additional heat was provided by stringing the cable around the perimeter of the bed to provide an additional 60 watts per square foot of bed area. In 1959 and 1960 a 5.7 Kilowatt space heater equipped with a circulating fan was used instead of the perimeter cable. Electric meters were used to measure the power consumed by the heating devices.

The three pneumatic greenhouses at Sodus were erected in the spring and used for a period of only 8 to 10 weeks each year to grow vegetable transplants.

Two pneumatic plastic houses were constructed on the Michigan State University campus in 1959. The first house was built with circular ends using a 32 by 90-foot sheet of 6-mil polyethylene. The film was placed in a 10-inch deep trench and weighted down with two tiers of regular concrete blocks, Fig. 7. The building was inflated with a 9-inch centrifugal fan delivering 1000 c.f.m. at ½ inch of water static pressure. Double doors were also used as an "air-lock" for this building. The completed building is shown in Fig. 8.

Fig. 7. Concrete blocks placed on the plastic to anchor the pneumatic building.

Fig. 8. The completed pneumatic building showing fan location.

The second structure built on campus was constructed with rectangular ends. The 14 by 42-foot building was built from a 30 x 62-foot sheet of 6-mil polyethylene film. The building was inflated with the same 9-inch centrifugal as used in the first building. The film edges were anchored by nailing it between two boards and imbedding them in a 12-inch deep trench. The trench was then backfilled with soil and saturated with water. Fig. 9 shows the inside of the building looking at the end where the fan was attached.

Periodic temperature and pressure measurements were made in the buildings.

Fig. 9. Inside view of a pneumatic building showing the attachment of the fan to the plastic.

RESULTS AND DISCUSSION

The pneumatic buildings with the circular ends were more difficult to build than the buildings with rectangular ends. Care had to be used in placing the plastic in the curved trench so that the building would not have a deformed shape at the ends. Another disadvantage of this type of building was that the plastic film at the ends of the building was exposed to high tensile stresses which caused tearing where the film was fastened to the door framing. This difficulty was not encountered in the buildings with the rectangular ends.

The technique of nailing the plastic edges between two boards before placement in the trench proved very advantageous. It kept the edges of the film straight and resulted in a neater building with few wrinkles. It also increased the resistance to the upward lift because the plastic could not be easily pulled out of the trench. Backfilling the trench with soil was found to be the easiest method of supplying the weight needed to anchor the building. When concrete blocks were used for anchorage, considerable care had to be taken in placing the blocks to avoid damaging the plastic film.

Calculations were made to determine the weight needed to counteract the vertical lift exerted on the foundations of pneumatic buildings. The vertical lift is dependent on the static pressure inside the building, wind pressures on the outside, and the size of the house. The effect of static pressure on the vertical lift was calculated and is shown in Fig. 10 for various size pneumatic buildings. The effect of wind pressure on the vertical lift cannot be determined analytically and would have to be found experimentally. Observations on the buildings erected indicated that the effect of wind pressure is small compared to the static pressure inside the building. It is realized, however, that for larger buildings, the effect of wind pressure on the vertical lift would be proportionately greater.

Measurements of the static pressure inside the pneumatic buildings indicated that the preferred operating pressures are from ¼ to ½ inch of water. At a static pressure of ¼ inch of water, the pneumatic building will hold its shape well under moderate wind conditions. At ½ inch of water static pressure, the building is tight and will withstand 30 mile per hour winds and 3 to 4-inch snow loads. Under extreme conditions of wind and snow, a static pressure of ¾ inch of water will maintain the building without deforming or swaying.

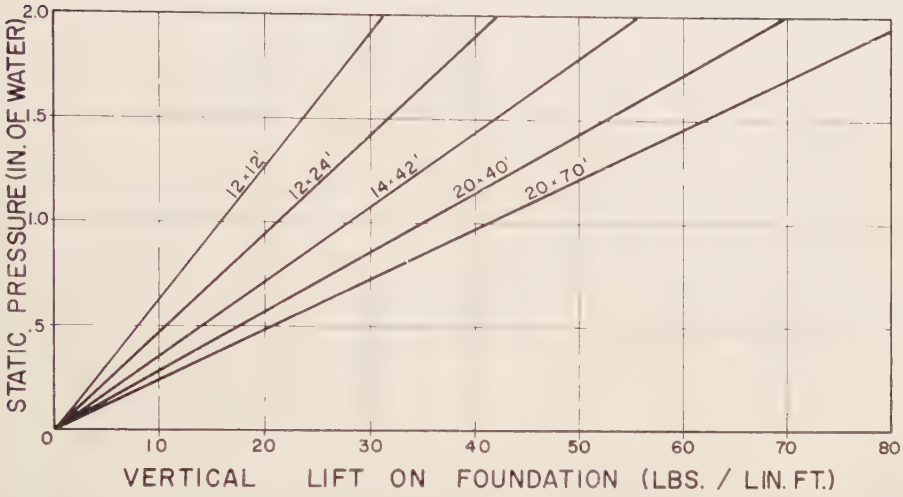

Fig. 10. Vertical lift on foundation due to static pressure within various size pneumatic buildings.

A maximum pressure of ¾ inch of water was used to determine the size of trench required for the pneumatic buildings built with rectangular ends. The density of backfill was taken at 20 lbs. per cu. ft. This would provide a safety factor since soil densities are in the range of 70 to 100 lbs. per cu. ft. The trench size as well as the size of plastic film to use for various sizes of buildings are shown in Table 1. The dimensions of the plastic film are based on the assumption that the height at the center of the house will be one-half of the width of the building. The height can be varied to meet special needs.

TABLE 1—Trench size and size of plastic film for rectangular pneumatic buildings

Size of house (Feet)	Height (Feet)	Area enclosed (Sq. Ft.)	Trench size (Inches)	Plastic size (Feet)
12 x 12	6	144	8 x 12	24 x 30
12 x 24	6	288	8 x 12	24 x 42
14 x 28	7	392	12 x 12	28 x 48
14 x 42	7	588	12 x 12	28 x 62
16 x 32	8	512	12 x 16	32 x 56
16 x 48	8	768	12 x 16	32 x 72
16 x 64	8	1024	12 x 16	32 x 70
20 x 40	10	800	12 x 20	40 x 70
20 x 60	10	1200	12 x 20	40 x 90
20 x 70	10	1400	12 x 20	40 x 100

The construction costs for the pneumatic buildings were approximately 20 cents per square foot of floor area per year. Detailed construction costs for the buildings built at Sodus are shown in Table 2.

TABLE 2—Construction and operation costs of 16 ft. by 52 ft. pneumatic greenhouse (777 sq. ft. at Sodus)

Item	Description	Cost/Yr.
Polyethylene	32 ft. x 65 ft./yr.	$ 65.00
Lumber, tile, etc.	$70/5 yrs.	14.00
Used fan and motor	16 inch and ¾ HP $40/5 yrs.	8.00
Belt	$2.50/yr.	2.50
Wiring	$24/3 yrs.	8.00
Labor	3 man x 8 hrs. x $1.25	30.00
Av. KWH for inflation and ventilation(*a*).	931 KWH x 1.5c	13.97
Total construction costs per year		$141.47
Total construction costs per year per square foot		$ 0.182

(*a*) Average of 1958-59 for period of about 90 days (March 15-June 15).

The power consumption for inflation, ventilation and heating of the greenhouses built at Sodus are shown in Table 3.

Periodic measurements of temperatures at the Sodus building in 1960 showed considerable daily variation. A temperature range from 40°F. at night to a high of 90 to 100°F. during the day was frequently encountered. The high temperatures occurred on warm sunny

TABLE 3—Electric power consumption for inflation, ventilation and heating the pneumatic greenhouses at Sodus, Michigan

Item	Kilowatt hours consumed	
	1958 (4/11-6/8)	1959 (4/8-5/29)
Fan motor	715	1147
Soil heating	4000	2376
Supplemental heating	836	505
Total	5551	4028
KWH sq. ft.	7.14	5.18

days. Ventilation of the building by opening of the 2 by 2-foot port would drop the temperature approximately 10°F.

CONCLUSIONS

1. Small pneumatic polyethylene buildings constructed into the half cylindrical shape with rectangular ends were the easiest to erect.

2. Imbedding the plastic in a trench and backfilling with soil was the most convenient method of anchoring the buildings to the ground.

3. Optimum inflation pressures during moderate weather were found to be ¼ to ½ inch of water. The maximum inflation pressure required to maintain the buildings under adverse weather conditions was ¾ inch of water.

4. Construction costs for the pneumatic polyethylene buildings were 20 cents per square foot of floor area.

FARM MANAGEMENT ASPECTS OF MECHANICAL HARVESTING AND HANDLING OF TREE FRUITS IN MICHIGAN

By D. J. RICKS and R. G. WHEELER[1]

DEPARTMENT OF AGRICULTURAL ECONOMICS

LARGE SAVINGS IN HARVEST LABOR are in prospect for fruit growers who can take advantage of the mechanical harvesting and handling techniques now being developed. The income benefits of these techniques, however, will vary widely according to the combination and size of farm enterprises and other organizational aspects of the individual business.

Most Michigan growers harvest fewer than 50 or 60 acres of tree fruits annually, and their total acreage is commonly divided among several species. More than two-thirds of all commercial cherry growers in southwestern Michigan harvest fewer than 10 acres of tart cherries, yet this is the tree fruit for which mechanical harvesting appears most promising at present.

Under these circumstances, many growers will have serious questions about the profitability of mechanization for their individual situations. Also, they may want to consider the advisability of adjusting the size and organization of their businesses to take advantage of opportunities related to mechanization.

Mechanization Alternatives

New mechanical aids can now be employed in two distinct phases of harvest-season activities. Tree shakers and catching devices are capable of separating fruit from the tree and depositing it in containers

[1]J. H. Levin and S. L. Hedden of the agricultural research service, U. S. Department of Agriculture, together with Professors A. E. Mitchell and R. P. Larsen of the department of horticulture, have provided useful information and advice for this research. The first three individuals and also Professor Myron P. Kelsey of the department of agricultural economics reviewed a draft of this article and made helpful suggestions. Don Ricks is now a graduate assistant in the department of agricultural economics at Oregon State College.

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for transportation from the orchard; bulk boxes and fork-lift trucks are available for handling harvested fruit. These two kinds of mechanization, however, are not equally applicable to all kinds of fruit.

Recent experiments indicate that the new mechanical harvesting equipment can be used in harvesting plums, cling peaches, and possibly sweet cherries to be sold for canning, as well as for the tart cherry crop for which they are especially well adapted.[2] Technical difficulties have not yet been overcome in using tree shakers for such easily bruised fruits as apples, pears, and peaches.

Apples and pears, however, can be handled in bulk boxes with the prospect of less bruising than when conventional field crates are used. Savings in labor and other expenses are also likely, especially when the bulk boxes are moved with fork-lift trucks. Some form of mechanical handling is technically feasible in varying degrees for most of the tree-fruit crops.

In total, the labor for picking, hauling, grading, packing and other harvest-season operations accounts for 45 to 80 percent of all labor used in producing Michigan tree fruits.[3]

Opportunities in mechanical harvesting and handling on several case-study farms varying in size and other characteristics have been examined by comparative budgeting. The case-study farms represent situations commonly found in the tree-fruit areas of western Michigan, and they are operated by individuals who cooperated in earlier research.[4] The results, to be presented below, will show some sizable gains from mechanization for existing tree-fruit acreages. Secondly, they will reveal additional opportunities when acreage expansion accompanies mechanization.

Opportunities With Mechanical Harvesting

Harvest labor has recently accounted for some 80 percent of all labor used in producing cherries. Wage rates for harvest labor have been increasing in recent years, and Michigan growers often have difficulty in maintaining an adequate labor force even at going rates. Therefore, the advent of mechanical harvesting is of special significance to Michigan cherry growers.

[2]Gaston, H. P., J. H. Levin, and S. L. Hedden (1959). Mechanical harvesting of cherries, plums and blueberries in 1959, *Eighty-ninth Annual Report of the Michigan State Horticultural Society.*

[3]Gavett, E. E. (1958). Labor used for fruits and tree nuts. Statistical Bulletin 232, Agricultural Research Service, USDA (Washington, D. C.).

[4]Wheeler, R. G. and E. F. Lord (1958). The southwestern Michigan fruit and vegetable farm business, 1957. Part I. Farm costs and returns. Mich. Agr. Expt. Sta. Quart. Bul. V. 40: 838-851. Part II. Crop costs and returns. Mich. Agr. Expt. Sta. Quart. Bul. V. 41: 204-218. Wheeler, R. G. and Don Ricks (1959). The southwestern Michigan fruit and vegetable farm business, 1958. Mich. State. Univ. agricultural economics department mimeo 760.

The case-farm analyses indicated that mechanical harvesting of tart cherries will increase net farm incomes when moderate acreages and fairly high yields are involved. Because acreage and yield appeared to be the most important variables, a general showing of their relative importance will be developed under standardized assumptions.

Table 1 shows the expected costs of mechanical harvesting and hand harvesting for selected acreages with average yields of 6 tons, 4 tons, and 2 tons. The 2-ton yield is low for profitable cherry growing. A yield of 4 tons is more nearly an average in well managed orchards. A yield of 6 tons is relatively high.

TABLE 1—Estimated harvesting costs for tart cherries on various acreages with three different yield levels, standard harvest performance

Acreage	Yield per acre	Mechanical harvesting					Hand harvesting		
		Harvest hours	Total labor expense	Gas expense	Expense for repairs	Depreciation, interest, insurance	Piecework labor expense	Cost of ladders and equipment	Housing costs
7 acres	6T.	63	$ 550	$ 10	$ 90	$ 910	$2,110	$ 50	$ 240
	4T.	58	510	10	80	910	1,510	30	120
	2T.	54	470	10	70	910	860	20	.....
12 acres	6T.	127	1,110	30	110	910	4,210	100	480
	4T.	117	1,020	30	100	910	3,030	70	180
	2T.	108	940	30	90	910	1,750	50	.....
22 acres	6T.	200	1,750	50	140	910	6,460	160	960
	4T.	183	1,600	40	130	910	4,730	100	660
	2T.	169	1,480	40	120	910	2,690	80	240
28 acres	6T.	254	2,220	60	110	1,820	8,430	200	1,200
	4T.	233	2,040	50	100	1,820	6,050	130	840
	2T.	215	1,880	50	90	1,820	2,920	100	300
40 acres	6T.	364	3,180	90	130	1,820	12,000	290	1,680
	4T.	333	2,910	80	110	1,820	8,620	190	1,320
	2T.	308	2,690	80	90	1,820	5,030	140	600
65 acres	6T.	591	5,170	130	420	2,730	19,500	470	3,360
	4T.	542	4,740	120	380	2,730	13,940	310	1,800
	2T.	500	4,370	110	340	2,730	7,980	230	1,080

Experiments in 1959 showed that a 7-man crew with a tree shaker and catching equipment could harvest 8 to 15 trees per hour.[5] A rate of 12 trees may be considered standard for usual conditions. This rate does not vary greatly with yield, but dense young trees, uneven ground, high vegetative cover, or a close spacing of trees will tend to reduce the number of trees harvested per hour. New methods of pruning, on

[5]Levin, J. H., H. P. Gaston, S. L. Hedden, and R. T. Whittenberger (1960). Mechanizing the harvest of red tart cherries, Mich. Agr. Expt. Sta. Quart. Bul. V. 42: 656-685.

the other hand, may offer opportunity for facilitating mechanical harvesting.

Assuming a 4-week harvest season and 10-hour working days, one mechanical harvesting unit could be used for 220 hours annually, or long enough to harvest 25 acres of cherries at the rate of 12 trees per hour. (Rates of 12 trees per hour for the 4-ton yields, 11 trees per hour for the 6-ton yields, and 13 trees for the 2-ton yields are assumed.) A few large growers may use two shifts to increase the acreage which can be harvested by one unit of equipment if supervisory responsibilities can be delegated, but operators of family-sized farms may be unwilling to use two shifts.

The fixed charges for mechanical harvesting machinery include an allowance for an additional investment in a small used tractor which can be used for mounting a shaker-boom. Investment in the hydraulically operated boom was estimated at $2,700, to be depreciated in 5 years; investment in the catching equipment was estimated at $600, to be depreciated in 3 years.

Labor expenses for mechanical harvesting operations include wages for a seven-man crew at $1.25 per man hour.

The piecework wages estimated for the hand harvest method are based on lower rates per pound for the 6-ton yield than for the lower yields. This is because growers normally have to pay more per pound to harvest low yielding trees than for high yielding trees.

The housing costs for the hand harvest workers are estimated to be greater per ton for the large growers than for the smaller ones because the large grower must rely to a greater extent on migrant laborers who require housing.

Experimental results indicate that yield and quality of tart cherries harvested mechanically may be equal to that of hand picked fruit. If the equipment is not properly adjusted, however, or if conditions are less than ideal, both yield and quality of the fruit may be lower for mechanical harvesting than for hand harvesting. The budget comparisons, therefore, are based on the assumption that yields will be reduced by 3 percent and price by 2 percent because of possible technical difficulties in the mechanical operations.

Changes in net income which can be expected from adopting mechanical harvesting in the various acreage and yield situations are shown in Table 2. In general, the farms with larger acreages of tart cherries can expect greater returns from mechanical harvesting than can smaller farms with similar yields. However, due to the

TABLE 2—Comparison of financial results from mechanical harvesting and hand harvesting on various acreages with three different yield levels

Acreage	Yield per acre	Total hand harvest costs	Mechanical harvest, standard performance			Mechanical harvest, improved performance	
			Total costs	Reduced receipts	Net advantage	Total costs	Net advantage
7 acres	6T.	$ 2,400	$1,560	$ 230	$ 610	$1,450	$ 950
	4T.	1,660	1,510	160	−10	1,410	250
	2T.	880	1,460	80	−660	1,370	−490
14 acres	6T.	4,910	2,160	460	2,290	1,930	2,980
	4T.	3,280	2,060	310	910	1,850	1,430
	2T.	1,790	1,970	150	−330	1,800	−10
22 acres	6T.	7,450	2,850	730	3,870	2,470	4,980
	4T.	5,500	2,680	480	2,340	2,370	3,130
	2T.	3,000	2,550	240	210	2,280	720
28 acres	6T.	9,830	4,210	920	5,620	3,740	6,090
	4T.	7,030	4,010	620	2,400	3,610	3,420
	2T.	3,320	3,840	310	−830	3,490	−170
40 acres	6T.	13,970	5,220	1,320	7,430	4,750	9,220
	4T.	10,130	4,920	880	4,330	4,540	5,990
	2T.	5,770	4,680	440	650	4,350	1,420
65 acres	6T.	23,330	8,450	2,140	12,740	7,340	15,990
	4T.	16,050	7,970	1,430	6,650	7,020	9,030
	2T.	9,290	7,550	710	1,030	6,740	2,550

"lumpiness" of the units of mechanical harvesting equipment, a smaller acreage may be more profitable than a large one within a certain acreage range.

This point is illustrated by comparing the income of the 22-acre situation with the 28-acre situation. Although a small increase in net income from mechanical harvesting can be realized on 22 acres with a 2-ton yield, a decrease in net income is expected from mechanical harvesting on 28 acres with the same yield. This difference is due to the necessity of purchasing two mechanical harvesting units for the 28-acre operation. Growers in the latter situation may choose to use some hand workers plus one mechanical harvesting unit.

The income figures in Table 2 indicate that farms with as few as 7 acres of tart cherries may realize a profit from mechanical harvesting, if average yields of 6 tons per acre are obtained. With average yields of 4 tons per acre, a tart cherry enterprise of nearer 14 acres is needed to realize an increase in net income from owning and operating mechanical harvesting equipment. Custom harvesting and joint ownership of equipment offer possibilities for smaller growers to gain the benefits of mechanical harvesting.

Extending the use of mechanical harvesting equipment to sweet cherries is another possibility, which can be illustrated by the situation on Farm C, where 4 acres of sweet cherries and 13 acres of tart cherries are grown. When mechanical harvesting is adopted for the tart cherries, the sweet cherries can be harvested mechanically with no additional expense for depreciation, interest, or insurance. If a harvest rate of 12 trees per hour can be maintained, labor expense for harvesting the sweet cherries can be reduced by $710. Expected receipts from sweet cherries would be reduced by 20 percent, however, because mechanical harvesting of sweet cherries has been less successful than for tart cherries.

The 20 percent reduction in receipts is based on a 10 percent reduction in the quantity of cherries harvested and on a 10 percent reduction in price because of lower quality. Even with these reductions in sweet cherry receipts, the savings in picking labor on Farm C are sufficient to result in an additional gain of $290 annually if the sweet cherries as well as the tart cherries are harvested mechanically.

Table 2 emphasizes the importance of high yields in order to realize a gain from mechanical harvesting. With yields of 6 tons per acre, for example, the 28-acre operation shows an **increase** in net income of $5,620 from mechanical harvesting. Use of mechanical harvesting on the same acreage with a 2-ton yield would result in a **decrease** in net income of $830. With a 2-ton yield on the 65-acre operation, the gain in net income from mechanical harvesting will be less than the gain on the 14 acres of cherries with a yield of 4-tons per acre.

If a 6-ton yield is harvested mechanically on the 65-acres, expected net income will be $12,740 greater than the expected net income with hand harvesting on that acreage. This is a gain of over $11,000 more than the expected income if a 2-ton yield is harvested mechanically on the same acreage. These large differences in expected gain with different yields occur because total mechanical harvesting costs increase only slightly with increased yields per tree, while total hand harvesting costs, particularly piecework wages, increase directly with the pounds of cherries produced.

Opportunities With Improved Performance

Future operating performance of mechanical harvesting equipment will probably be greater than that assumed in the foregoing analysis, because further improvements in the equipment and har-

vesting techniques can be expected. With favorable orchard conditions, mechanical harvesting rates of 15 trees per hour or more have been achieved in experimental tests. Also, yield and fruit quality equal to those from hand harvesting have been obtained.[6]

The last two columns in Table 2 show the effect of mechanical harvesting upon net income if a harvest rate of 15 trees per hour can be attained and if cherry receipts can equal those from hand harvesting. The results show that the acreage and yield necessary for a gain from mechanical harvesting will be less than for the lower performance rates. Mechanical harvesting equipment will be profitable for farms with as few as 7 acres of tart cherries producing 4 tons per acre, if the improved performance levels can be attained. On larger farms with equal or higher yields, the gains from mechanical harvesting will be considerably greater than with the previous "standard" performance. It is important to note, however, that the low yield situations for each acreage will result in relatively small net gain from adopting mechanical harvesting even with the improved performance rates.

In an analysis of mechanical and hand harvesting methods, the operator's personal preferences and his subjective evaluation of risk must also be considered. If the operator often has difficulty in hiring enough hand laborers, mechanical harvesting may be more attractive than suggested by the estimated income gains. On the other hand, the process of acquiring skill and speed in operating the mechanical harvesting equipment may require valuable time during the critical harvest season. The operator may also be uncertain about expectations for further development of the new technology.

Opportunities With Mechanical Handling

To show the possible increases in net income which can be realized by the use of fork-lift equipment and bulk boxes on farms of various sizes and with various fruit crops, the costs of owning and operating the mechanical handling equipment are compared to savings in labor and other advantages of mechanical handling on several case farms (Table 3).

The equipment costs on each farm include replacement charges on a $1,250 investment in a fork-lift attachment for a farm tractor. On Farms B, E, and K, a bulk-box dumper will be added because much

[6]Results of 1960 tests point toward harvesting rates of 15 to 20 trees per hour, lower investments in the tree shaker, higher investments in the collecting devices, and smaller crews for attending the collecting devices.

TABLE 3—Summary of expected changes in annual costs and returns from substituting mechanical handling equipment for hand labor on seven fruit farms

Farm and main crops	Acres	Production	Container savings	Total labor savings	Added receipts	Total credits	Equipment costs	Gain from mechanical handling
Farm A								
Apples..	40	14,000 bu.	$280	$ 530	$140	$ 950		
Pears...	37	12,000 bu.	100	460	...	560		
Cherries	14	65 T	...	460	...	60		
Total..	.....	.....	380	1,050	140	1,570	260	1,310
Farm B								
Apples..	19	5,000 bu.	...	200	50	250		
Peaches	9	1,600 bu.	...	30	...	30		
Cherries	7	25 T	...	20	...	20		
Total..	.....	.....	...	250	50	300	320	−20
Farm D								
Apples..	7	2,800 bu.	50	100	30	180		
Peaches	28	9,000 bu.	...	120	...	120		
Total..	.....	.....	50	220	30	300	210	90
Farm E								
Apples..	43	10,000 bu.	...	410	100	520		
Peaches	13	1,300 bu.	...	20	...	20		
Plums..	16	1,600 bu.	...	60	...	60		
Cherries	24	80 T	...	60	...	60		
Total..	.....	.....	...	550	100	650	320	330
Farm F								
Apples..	49	13,000 bu.	120	530	130	780		
Peaches	36	5,000 bu.	...	70	...	70		
Cherries	29	80 T	...	60	...	60		
Total..	.....	.....	120	660	130	910	260	650
Farm K								
Apples..	110	36,000 bu.	930	2,050	360	3,340		
Pears...	23	5,000 bu.	...	220	...	220		
Plums..	4	1,200 bu.	...	40	...	40		
Peaches	18	3,500 bu.	...	70	...	70		
Cherries	45	160 T	...	150	...	150		
Total..	.....	.....	930	2,530	360	3,820	870	3,050

of the fruit is packed on the farm. Farm K will add an industrial fork-lift truck to handle a large volume of apples in a farm storage operation. Equipment costs shown in Table 3 also include estimated expenses for gasoline, repairs, insurance, and interest on the investment.

Labor savings estimated for fork-lift handling with a farm tractor range from 15 hours per 1,000 bushels for peaches in field crates handled on pallets to 30 hours per 1,000 bushels for apples and pears

handled in bulk boxes. On Farm K, use of the industrial fork-lift truck at the farm storage plus the tractor-mounted fork-lift in the orchard will permit total labor savings of 40 hours per 1,000 bushels.

In addition to the savings in labor for handling, many growers are able to realize savings in picking labor expenses by the use of bulk boxes. Because these bulk containers are more convenient for the pickers, growers are often able to pay less per bushel for picking than is necessary when the fruit is placed in field crates. Possible savings in picking expenses of approximately $.01 per bushel are estimated.

The economic value of the reduced bruising with the use of bulk boxes will vary considerablly for different farm situations and is difficult to estimate. A conservative estimate of increased receipts of $.01 per bushel is made.

Savings in container replacement costs can be realized by the use of the bulk boxes. The original investment will be little different than for the same capacity in field crates, but the useful life of bulk boxes will probably be nearly twice as long. Savings to the grower will depend upon his marketing outlets and arrangements.

The changes in net income expected from substituting mechanical handling equipment on the various farms range from a decrease in net income of $20 on Farm B to a gain of over $3,000 on Farm K. The farms with a large total production, especially of apples and pears, will gain considerably more than farms with a small volume.

The relatively small fruit production on Farm B will not permit enough labor savings to balance the additional equipment costs. No savings in container costs are possible on this farm, because of the market outlet used.

Farm K has a large production of apples and other fruit. The machinery costs are greater than those for the other farms because of the need for a fork-lift truck. Labor savings, however, will permit a gain in net income with mechanical handling. In addition, savings can be realized on the large volume of containers purchased for apples.

The case analyses show that mechanical handling can be expected to increase net farm income on a number of Michigan tree-fruit farms. Producers of limited volumes, however, cannot realize sufficient savings in hired labor expenses and container costs to offset expenses of owning and operating the necessary equipment. Each of the case farms with an average annual production of 10,000 bushels or more of apples and pears appears likely to benefit from the use of mechanical handling.

In addition to handling fruit at harvest time, the fork-lift may be useful for handling supplies such as fertilizer and spray material. The subjective value of the reduced physical labor involved in mechanical handling may also be an important factor in determining the advisability of adopting this handling method on an individual farm.

Combined Opportunities for Mechanizing Harvest Operations and Expanding Acreage

Total output on a number of tree-fruit farms in western Michigan is apparently too small to permit income gains from owning mechanical harvesting and handling equipment. Operators of these farms may want to examine their opportunities for increasing net incomes through combining expansion of acreage with the adoption of new harvesting techniques. Results of comparative budgeting for three of the case-study farms show that acreage expansion can contribute to the ultimate advantages of mechanical harvesting and handling.

Planting young orchards was selected as the means of expanding fruit acreage on each of the case farms because none of the operators knew of suitable bearing orchards that could be purchased for expansion. Under these circumstances, the benefits of expansion can be expected to accrue only after an extended development period. Evaluation of the possible benefits will be in terms of net income flows throughout the 20-year period from 1960 to 1980. To permit a simplified comparison of net incomes over time, prospective net incomes under alternative plans have been discounted to the year 1960 at a rate of 5 percent per year.

On Farm A, a 70-percent increase in tree-fruit acreage would add $1,000 per year to average discounted income for the 20-year period. The four acres of tart cherries of the present plan were to be increased to 14 by additional plantings. At maturity of the new plantings, mechanical harvesting of the cherry crop would increase net income by $800 per year, whereas purchase of the necessary equipment for harvesting the present acreage mechanically would reduce net income.

Adoption of mechanical handling equipment on the present acreage will result in an increase in average annual net income of $700, while using this equipment on the larger fruit acreage will result in an increase in net income of about $1,300 per year after mature production is obtained. Thus, use of the new techniques on the expanded acreage will add $1,400 more to net income than could be added on the present acreage. This illustrates the inter-relationship between

increasing acreage and adopting the new labor-saving technologies. A combination of these adjustments is likely to result in more gain than any one adjustment alone.

The analysis of increasing the fruit acreage by 90 percent on Farm B also indicates an increase of $1,000 in the present value of average annual incomes during the 20-year planning period. The expansion plans include no tart cherries; therefore no gains from mechanical harvesting can be expected from the larger acreage. Mechanical handling of fruit on the larger acreage on Farm B would result in a gain of $320 per year after the trees reach maturity, while mechanical handling on the present acreage would result in a decrease in net income.

Expanding the fruit acreage on Farm D by 70 percent will result in an average increase in discounted net incomes of $550 per year. Mechanical harvesting on the larger acreage when the trees are mature will permit an additional increase in annual net income of $2,020. Use of mechanical handling will account for another $130 increase. A total increase in net income of $2,150 can thereby be realized on the larger acreage with use of mechanical harvesting and mechanical handling. Adoption of mechanical handling on the present acreage would result in an increase in net income of only $60, while mechanical harvesting would decrease the net income.

Farm D like Farm A would have about 14 acres of tart cherries after the planned expansion. Mechanical harvesting of 14 acres of tart cherries at standard performance rates would result in a gain of $2,290 at a yield of 6 tons per acre, but a decrease in net income of $330 at a yield of only 2 tons per acre. Although expansion of acreage will increase the possible benefits of mechanical harvesting, the gains can be realized only with yields at relatively high levels.

Implications for Fruit Farms in General

The analyses of the case-study farms suggest income-increasing opportunities on many other medium-sized fruit farms through expansion of acreage and adoption of mechanical equipment for harvesting and handling operations. Mechanical harvesting offers prospects for higher incomes on farms with as few as 10 to 14 acres of tart cherries if average yields are at least 4 tons per acre. Lower yields may reduce or eliminate the advantage of mechanical harvesting on considerably larger acreages. Mechanical harvesting of other fruits in addition to the tart cherries offers additional possibilities for net income gains.

Operators who produce 10,000 bushels of apples or pears are likely to benefit by using mechanical handling methods. Some operators with 20 to 60 acres of tree fruit may have sufficient production to realize a gain from mechanical handling. The possibilities of increasing net incomes with these techniques, however, are greater on larger farms.

Data from the 1954 Census of Agriculture indicate that there are about 1,700 commercial fruit farms in western Michigan with 20 to 60 acres of tree fruits. Eleven hundred of these are in Berrien, Van Buren, and Allegan counties, where the case-study farms are located. Results of the case analyses are therefore relevant to the situations on many other farms, although each individual farm situation may be unique in some respects. On the whole, the case farms probably represent more favorable opportunities for expansion than prevail generally throughout the area. Each of the case farms has a moderate acreage of tree-fruits per operator, with relatively high quality land and orchard site resources as well as indications of effective management.

Such farms will, of course, have greater possibilities for increasing income by expansion than farms with more limited resources. However, the benefits of mechanical harvesting and mechanical handling can probably be obtained on farms with various qualities of management and orchard resources. Relatively high yields and a relatively large production are pre-requisites for increased incomes with these technologies, however. In general, increasing acreage in connection with adopting the recently developed techniques for mechanical harvesting and mechanical handling will probably represent important future adjustments for managers of many medium-sized tree-fruit farms in Michigan.

SURVEY OF HOMOGENIZED MILK IN MICHIGAN

I. The Extent, operating conditions, and utilization of returns

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Homogenized milk was first produced and sold commercially in Michigan in 1932 by the McDonald Dairy, Flint. The product was introduced largely for its soft-curd characteristic. Prior to the Michigan sales, homogenized milk was acclaimed in Canada where its introduction in Ottawa, 1927, was successful and has continued so.

While its introduction at Flint by McDonald was the first in Michigan and furnished the spark that revolutionized the bottled fresh milk industry, the honor for the first continuous commercial sales of homogenized milk in the United States must go to Wiegold, Torrington Creamery Company, Torrington, Connecticut, who began selling homogenized milk in 1919. Such milk was first furnished to restaurants to insure homogeneity.

Within 25 years of the introduction by McDonald, homogenized milk became the principal household milk in each of the United States. Today, it is no longer a special milk but is the chief fluid milk product in virtually all bottled fresh milk markets. In fact, many dairies have discontinued bottling creamline milk because the demand is so low as to make its production uneconomical.

At first, the sales of homogenized milk were relatively slow. Plant managers were reluctant to invest in new equipment when future sales were uncertain. Even some city ordinances forbade the installation of homogenizers in milk plants. However, consumer acceptance and demand encouraged plant operators and regulatory officials so that fears and objections were finally overcome. World War II brought drastic changes in the milk industry as in other industries. The milk

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industry emerged into an undreamed-of-era of efficiency, labor saving, packaging, automation, and distribution which could not have been attained without homogenization.

Since homogenization prevents creamline formation and churning and inhibits metal-induced oxidized flavor, milk thus becomes more stable so far as physical and flavor defects incident to modern production and processing and prolonged storage are concerned.

The advent of homogenization contributed to and made possible in part the following post-war market milk developments: a) bulk tanks; b) bulk handling and transportation; c) every-other-day pick-up; d) 100 percent clarification; e) plant raw milk storage; f) four-days-a-week plant operation; g) ultra-high-temperature pasteurization; h) vacuum treatment; i) mineral fortified milk; j) half-and-half homogenized milk; k) frozen milk; l) paper containers; m) twice-a-week home delivery; n) supermarket retail sales; o) outer-market bottled milk distribution; p) milk vending machines; q) milk dispensers; r) longer shelf life; s) uniformly good flavor; and t) increased milk consumption.

The above list of successful progressive changes made possible, in part, by homogenization might lead one to believe that perfection in homogenization had been attained and no problems remained. However, problems brought to the attention of Michigan Agricultural Experiment Station research workers lead them to conclude otherwise. Consequently, this survey was undertaken to ascertain the present status of homogenized milk in Michigan with a view of improving the process.

THE SURVEY

Through the cooperation of the Michigan Dairy Products Association, a carefully prepared questionnaire was enclosed in the Association's monthly news letter to all members which include virtually all the milk processors within the state. The immediate response was excellent, indicating interest in the project. The data were compiled and classified so as to give a representative picture of the prevailing sequence and extent of homogenization.

RESULTS

The data presented herein were furnished by 80 respondents from milk plants in 36 counties, representing all sections of Michigan (Fig.

1). Data on all items sought in the questionnaire were not furnished. Hence, in the compilations, the total number of plants involved may be less than 80.

Fig. 1. Distribution of plants furnishing data on homogenization of milk, by counties.

Percentage of fresh, pasteurized milk homogenized in Michigan

Data obtained on 72 Michigan milk plants processing a total of 5,535,283 pounds of milk daily indicate that 4,991,726 pounds, or slightly over 90 percent, were homogenized. These plants ranged in size from less than 1,000 pounds to over 600,000 pounds of milk per day (Table 1). Twelve of the plants each handled over 100,000 pounds

TABLE 1—The amount of milk homogenized daily in 72 plants

Weight of milk (lbs.)	Distribution of Michigan milk plants according to the amount of milk homogenized	
	No.	Percent
<10,000	22	30.5
10,001-25,000	19	26.4
25,001-50,000	9	12.5
50,001-75,000	4	5.6
75,001-100,000	6	8.3
>100,000	12	16.7
Total	72	100.0

daily with an average of 293,200 pounds. These 12 plants pasteurized 3,518,436 pounds of milk per day. Of this amount 3,285,887 pounds, or 93.4 percent, were homogenized.

Although more than 90 percent of all the milk in the 72 plants was homogenized, the percentage figure varied considerably for individual plants. The percentage of milk homogenized in 72 Michigan processing plants is shown in Table 2. From 80 to 100 percent of the milk processed was homogenized in 59 (82 percent) of the plants. All the milk was homogenized in four plants, whereas only in one plant was less than 50 percent of the milk so treated. This plant handled only 500 pounds of milk daily.

TABLE 2—The percentage of milk homogenized in 72 Michigan plants

Percentage homogenized (range percent)	Distribution of Michigan milk plants according to the percentage of milk homogenized	
	No.	Percent
<50	1	1.4
50 to 59	1	1.4
60 to 69	3	4.2
70 to 79	9	12.5
80 to 89	13	18.1
90 to 99	41	56.9
100	4	5.6
Total	72	100.1

Clarification

Of the 72 Michigan milk plants reporting, 62 (86.1 percent) clarified the milk (Table 3). Usually, this process was accomplished before pasteurization and at a temperature of 40° F. or lower. In one plant the milk was preheated to 135° F. before clarification. In only two of the plants was the milk clarified after pasteurization—one at 64° to 66° F. and the other at 145° F.

TABLE 3—Extent and conditions of clarification in Michigan milk plants

Item	Distribution of Michigan milk plants with reference to the nature and extent of clarification	
	No.	Percent
Clarification:		
Yes	62	86.1
No	10	13.9
Total	72	100.0
When clarified:		
Before pasteurization	60	96.8
After pasteurization	2	3.1
Total	62	99.9
Before homogenization	51	98.1
After homogenization	1	1.9
Total	52	100.0
Temperature of clarification:		
<40° F.	53	88.3
41° to 50° F.	4	6.7
>51° F.	3(*a*)	5.0
Total	60	100.0

(*a*) 64° to 66° F.; 135° F. before pasteurization; 145° F.

The milk was clarified before homogenization in virtually all plants. In only one plant was the milk clarified after homogenization. Surprisingly, 10 plants (13.9 percent) of those furnishing data, did not clarify the milk. Generally, these plants had small volume, under 5,000 pounds of milk daily, although one relatively large plant, around 100,000 pounds, reported no clarification.

Pasteurization

Of the 73 plants about which data were available 47 (64 percent) employed high-temperature, short-time pasteurization (Table 4). Seventy percent of them use temperatures from 166° to 175°F., generally for 16 seconds. In 15, or nearly one-third of the plants, the milk was held at pasteurizing temperature for 17 to 20 seconds.

In seven plants, the milk was pasteurized at temperatures from 176° to 182°F. One plant used ultra high temperature pasteurization at 215°F. after which the milk was cooled to 165°F. and held for 16 seconds.

TABLE 4—The method, temperature, and holding time of milk pasteurization and extent of milk deaeration in Michigan

Pasteurization	Distribution of Michigan milk plants according to the method of pasteurization	
	Number	Percent
Methods:		
Vat	25	34.2
H-T, S-T	47	64.4
UHT	1	1.4
Total	73	100.0
Temperature:		
Vat		
143° to 144° F.	8	32.0
145° to 150° F.	14	56.0
151° to 175° F.	3	12.0
Total	25	100.0
H-T, S-T		
161° to 165° F.	7	14.9
166° to 170° F.	19	40.4
171° to 175° F.	14	29.8
176° to 180° F.	6	12.8
181° to 185° F.	1	2.1
Total	47	100.0
UHT		
215° F.	1	1.4
Total	73	100.0

Table continued

TABLE 4—Concluded

Pasteurization	Distribution of Michigan milk plants according to the method of pasteurization	
	Number	Percent
Holding time:		
Vat		
30 min.	24	96.0
31 to 40 min.	1	4.0
Total	25	100.0
H-T, S-T		
15 sec.	2	4.3
16 sec.	30	63.8
17 sec.	8	17.0
18 sec.	1	2.1
19 sec.	1	2.1
20 sec.	5	10.6
Total	47	99.9
Deaeration:		
Yes	14	19.4
No	58	80.6
Total	72	100.0

Generally, vat pasteurization prevailed in the smaller plants, although there were exceptions. While the holding period of 30 minutes was common, the temperatures ranged from 143° to 175°F. In the majority of plants using vat pasteurization, the milk was heated from 145° to 150°F. Eight of the plants, or about one-third, maintained a temperature from 143° to 144°F., sufficiently low to avoid reduction of creamline of the milk. In all these plants creamline milk was produced which probably accounted for the lower temperatures of pasteurizing.

Homogenization

Homogenizers. Information from 73 milk plants indicated that the Gaulin (Manton-Gaulin) was the most widely used homogenizer in Michigan followed in order by the Superhomo (Cherry-Burrell) and the Multi-Flo (Creamery Package) (Table 5.) Of the 12 plants proc-

essing over 100,000 pounds of milk daily, the Gaulin and Multi-Flo homogenizers predominated. Two plants, both of small daily milk volume, had American Marsh homogenizers.

TABLE 5—Distribution of homogenizers used in Michigan milk plants

Distribution of homogenziers used in Michigan milk plants:

Name	In all plants		In plants over 100,000 pounds milk daily	
	(No.)	(Percent)	(No.)	(Percent)
Manton-Gaulin....	41	56.9	5	41.7
Cherry-Burrell....	15	20.8	2	16.6
Creamery Package	12	16.7	5	41.7
American Marsh...	4	5.6	..	....
Total.....	73	100.0	12	100.0

Homogenization pressures. The pressures used for homogenizing milk in Michigan varied widely depending upon the type of homogenizer and the plant (Table 6). Probably misinterpretation of the question might have led to confounding data also. Nevertheless, the data are tabulated as reported.

The majority of those using the Gaulin machine, 60 percent, reported using a pressure on the 1st stage of 500 to 800 p.s.i. Seventeen of the 39 reporting (43.6 percent) used from 1,700 to 3,200 p.s.i. on the second stage. Of the 41 users of the Gaulin machine, 25 (61 percent) reported using total pressures of 2,500 p.s.i. or higher. In one plant a total pressure of 3,200 p.s.i. was used.

Although fewer machines were involved, majority users of the Cherry-Burrell homogenizers applied pressures of 1,500 to 2,500 p.s.i. on the first stage with lower pressures on the second stage. Eight of the 15 users reporting (53 percent) carried a total pressure ranging from 1,900 to 2,000 p.s.i.

Total pressures on the Creamery Package machine ranged from 1,450 to 2,500 p.s.i.; 9 of the 12 (75 percent) maintained pressures from 1,800 to 2,000 p.s.i. Pressures maintained on the American Marsh homogenizer were 2,000 to 2,500 p.s.i.

TABLE 6—Pressures reported for homogenizing milk in Michigan plants by type of homogenizer

Distribution of Michigan milk plants according to the homogenizing pressure used, by machine, on the

	1st stage			2nd stage			Total pressure		
	p.s.i.	No.	Percent	p.s.i.	No.	Percent	p.s.i.	No.	Percent
Manton-Gaulin	500–800	24	60.0	500–800	8	20.5	1800–2000	7	17.1
	1000–1500	8	20.0	1000–1500	14	35.9	2000–2400	9	21.9
	1700–2000	6	15.0	1700–2000	13	33.3	2500	19	46.3
	2300–2500	2	5.0	2400–2500	3	7.7	2500–2800	4	9.8
							3000–3200	2	4.9
	Total...	40	100.0		39	100.0		41	100.0
Cherry Burrell	900	1	14.3	200	1	33.3	1900	1	6.7
	1500–1900	3	42.9	500	1	33.3	2000	7	46.7
	2000–2500	3	42.9	1600	1	33.3	2100–2500	6	40.0
							3000	1	6.7
	Total...	7	100.1		3	100.0		15	100.1
Creamery Package	.....	..	....	.....	..	....	1450	1	8.3
	.....	..	....	.....	..	....	1650	1	8.3
	.....	..	....	.....	..	....	1800	3	25.0
	.....	..	....	.....	..	....	1900	1	8.3
	.....	..	....	.....	..	....	2000	5	41.7
	.....	..	....	.....	..	....	2500	1	8.3
	Total...	..	....		..	....		12	99.9
American Marsh	.....	..	....	.....	..	....	2000	2	50.0
	.....	..	....	.....	..	....	2500	2	50.0
	Total...	..	....		..	....		4	100.0

Regardless of the make of homogenizer, 54 of the 68 plants, or 79 percent, reported total homogenizing pressures of 2,000 to 2,500 p.s.i. (Table 7). About 9 percent used pressures above 2,500 p.s.i. and the remainder used pressures from 1,450 to 1,900 p.s.i.

TABLE 7—Pressures reported for homogenizing milk in Michigan, regardless of make of homogenizer

Distribution of Michigan milk plants in Michigan according to the homogenizing pressure reported being used on the

1st stage			2nd stage			Total pressure		
p.s.i.	No.	Percent	p.s.i.	No.	Percent	p.s.i.	No.	Percent
500	11	21.2	200–500	6	14.3	1450–1900	8	11.8
500–700	5	9.6	600–800	4	9.5	2000	18	26.5
800–1000	11	21.2	1000–1500	14	33.3	2000–2400	13	19.1
1100–1500	7	13.5	1600–2000	14	33.3	2500	23	33.8
1750–2000	13	25.0	2400–2500	3	7.1	2500–2800	4	5.9
2100–2500	5	9.6	3200	1	2.4	3000–3200	2	2.9
Total...	52	100.1		42	99.9		68	100.0

Sequence of homogenization. Forty-one of the 72 plants reporting (57 percent) homogenized the milk before pasteurization (Table 8). This is not surprising since nearly two-thirds of the plants reporting using H-T, S-T pasteurization (Table 4). This method lends itself well to the necessary preheating of the milk for homogenizing.

Table 8—Time of homogenizing milk with reference to pasteurization

Relation of homogenization to pasteurization	Distribution of plants	
	No.	Percent
Before	41	56.9
After(*a*)	31	43.1
Total	72	100.0

(*a*) In every case where the milk was vat pasteurized, homogenization followed pasteurization. Six of the 47 plants using H-T, S-T pasteurization, or 13 percent, homogenized after pasteurization.

Temperature of homogenization. The minimum temperatures and times of milk pasteurization are fixed by state law. However, the maximum heat treatment given to milk depends to a great extent on its harmful effects on the flavor. These flavor-affecting temperatures are relatively high above those of the minimum requirement. Consequently, a wide range of pasteurization temperatures may be used among the various plants (Table 4). Likewise, the temperatures of homogenization may be expected to vary also. In fact, since there are no regulations as to pressures and temperatures of homogenization, processors generally employ those which fit into their sequence of operation and yet attain required homogenization efficiency. Data presented in Table 9 confirm this. The temperature range of 140° to 145°F. was used by a third (36.1 percent) of the operations. The remaining plants homogenized at nine different temperature zones (Table 9).

Unfortunately, data in Table 9 indicate little regarding homogenization temperatures with respect either to the type (holder or short time) of pasteurization or to the sequence of homogenization. However, the data in Table 10 are specific as to the type of pasteurization. All of the 24 plants using vat pasteurization homogenized after pasteurization, generally at 140° to 150°F. On the other hand, 41 of the 47 plants (87 percent) using H-T, S-T pasteurization homogen-

TABLE 9—Temperature of milk when homogenized

Temperature range (°F.)	Distribution of plants	
	No.	Percent
70	1	1.4
80–120	7	9.7
125–135	9	12.5
140–145	26	36.1
146–150	8	11.1
151–155	3	4.2
156–160	2	2.8
161–165	5	6.9
166–172	5	6.9
173–178	6	8.3
Total.....	72	99.9

TABLE 10—The temperature of homogenization with respect to the type of pasteurization

	Temperature of homogenization, °F.	Distribution of plants homogenizing			
		Before		After	
		No.	Percent	No.	Percent
VAT PASTEURIZATION	80–120	....	....	4	16.7
	125–135	....	....	1	4.2
	140–145	....	....	13	54.2
	145–150	....	....	4	16.7
	151–155	....	....	1	4.2
	156–160	....	....	1	4.2
Total.....		....	....	24	100.2
H-T, S-T PASTEURIZATION	70	1	2.4	....	....
	80–120	3	7.1	....	....
	125–135	7	17.1	1	16.7
	140–145	13	31.7	....	....
	145–150	4	9.8	....	....
	151–155	1	2.4	1	16.7
	156–160	1	2.4	....	....
	161–165	3	7.3	1	16.7
	166–172	4	9.8	3	50.0
	173–178	4	9.8	....	....
Total.....		41	99.8	6	100.1

ized before pasteurization and at temperatures ranging from 70° to 178°F. The prevailing temperature of homogenization, however, seemed to be in the range of 135° to 150°F. The few homogenizing after H-T, S-T pasteurization homogenized at the pasteurization temperature, although there were exceptions.

The 12 plants processing over 100,000 pounds of milk used H-T, S-T pasteurization ranging from 161.5° to 180°F., averaging 170.5°F., and homogenized aforehand at temperatures ranging from 130° to 178°F., averaging 152.8°F. Not a single large plant homogenized after pasteurization.

Cooling and bottling. Twelve processors reported cooling the milk partially after pasteurization and before homogenization. Of these 12, eight pasteurized in the vat, three by H-T, S-T, and one by UHT. The vat pasteurization temperatures were lowered 10°, 10°, 15°, 15°, 25°, 25°, 25°, and 38°F., respectively. The three using H-T, S-T pasteurization cooled the milk 10°, 23°, and 42°F. before homogenizing.

For the most part, those homogenizing after pasteurization did not cool the milk appreciably or at all after pasteurization and before homogenizing. However, exceptions were noted. About one-fifth of those vat pasteurizing cooled the milk progressively in the vat as the milk was being homogenized.

Deaeration or vacuum treatment and homogenization. Fourteen plants reported deaeration of milk (Table 4.) Of these, 10 homogenized after deaeration.

Of 76 plants reporting, 68 (89 percent) cooled the milk to 40°F. or below. Of those, 39 (57 percent) cooled the milk to 38°F. or under.

Generally, the milk was bottled immediately after pasteurization, homogenization, and cooling. A very small percentage of the plants pumped the homogenized milk directly through the cooling plates into the storage tank from where it was drawn later for bottling.

Checking the efficiency of homogenization. Of 63 plants reporting, 10 (16 percent) made no tests to check the efficiency of homogenization. About a third of all the plants made use of "top-and-bottom" tests, but varied the length of the quiescent storage period. About one-fifth of the plants used the microscope to check homogenization efficiency. Others resorted to straight fat tests of the milk, appearance of creamline, commercial laboratories, consumer complaints, and viscosity.

Complaints on homogenized milk. Of 73 plants responding, 40 (55 percent) did not indicate having had complaints on homogenized milk during the past 12 months. However, many were received by the remaining plants.

The complaints followed a general pattern. Those recurring most frequently were on off-flavors which were reported variously as oxidized, sunshine, medicinal, feed, bitter, rancid, sour, and merely "off." Of all the flavor complaints, the light-induced off-flavor occurred most frequently.

The second complaint in order of numbers reported, but not necessarily of second importance, was the presence of a cream plug or thin layer of cream at the top of the bottle. These complaints were reported as plugged, fat solids on top, cream on top, cream plug, spaghetti ring, plug and ring, or merely as cream rising. A few complaints dealt with foam, leucocytes, and sediment.

These consumer complaints arise as a result of a defective product which in turn may be attributed to shortcomings in processing, packaging, and/or distribution.

Use of homogenized milk returns. Disposition of homogenized milk returns seemed to present a problem which was not solved uniformly (Table 11). Fourteen of the 68 plants (21 percent) permitted no re-

TABLE 11—Disposition of homogenized milk returns

Method of solving homogenized milk return problem	Distribution of plants as to disposal of returned homogenized milk	
	No.	Percent
No returns permitted	14	20.6
Returns permitted, product		
Dumped	5	7.4
Used in		
Ice cream mix	14	20.6
Buttermilk	8	11.8
Chocolate milk	6	8.8
Cheese	2	2.9
Reprocessed	2	2.9
Separated	1	1.5
Given to employees	1	1.5
Sold	5	7.4
Used as animal feed	10	14.7
Totals	68	100.1

turns. Thirty of the 54 plants permitting returns (56 percent) used the returns in the manufacture of ice cream, buttermilk, chocolate milk, or cheese. Of these products, ice cream mix utilization seemed to be preferred. Some returns were reprocessed, some sold at the dairy bar, some separated, some given to employees, and some sold for animal feed.

DISCUSSION

The acceptance of homogenized milk in Michigan, as judged by the high percentage of fresh pasteurized milk homogenized, indicates that the milk processors are doing a very creditable job. Virtually all the homogenized milk is clarified and at temperatures around 40°F. prior to homogenization. Such treatment eliminates the clarifier as a potential post-pasteurization-homogenization source of contamination. When clarifying the raw milk cold, possibly during intake, a supply of raw milk is available for on-the-minute automated processing at the start of the day's operation.

High-temperature, short-time pasteurization, legalized in Michigan September, 1945, fits in well with modern milk processing. The larger plants cannot handle volumes of milk economically by previous pasteurization systems. Since practically all the milk in the large processing plants is homogenized, the time and temperature of pasteurization favorable to creaming need not be kept at the minimum requirements of 160°F. for 15 seconds. Creaming ability in milk is no longer a factor to be considered in most milk processing. Consequently, temperatures in the 170° to 176°F. range, under that yielding the cooked taste, would be expected to prevail.

This is exactly what has come to pass. Not only does such milk have a more pleasing flavor than that merely complying with the minimum requirements, but may be expected to yield a lower microbial cell count as well. In fact, "souring" of homogenized milk is not a major problem connected with the product when relatively free of post-pasteurization contamination. Homogenized milk has an exceptionally fine shelf life.

Regardless of which homogenizer is used, the pressure and temperature of homogenizing milk in Michigan seem to be in need of review in some instances. While a generally accepted pressure-temperature pattern is being followed in many plants, too wide a diversity of methods seems to exist. The extra demands on homogenized milk

today involving store handling, heat shocking and extended home refrigerator storage makes efficient homogenization imperative.

The desired procedure is to homogenize the milk at the pasteurization temperature with at least 2,000 p.s.i. on one valve. Frequently, the mistake is made by having these pressures attained cumulatively on two valves. Also, no uniformity of operation existed relative to the specific valve on which the maximum pressure was applied. Some had the major pressure on the first valve while others preferred the second. This inconsistency of applying pressures might be explained, in part, by a misinterpretation of the question and or by a misunderstanding as to which constituted the first and second valve. Regardless of the explanation, the operator should consult the manufacturer of the homogenizer for correct procedure.

Where the milk is vacuum treated to void it of undesirable odors (and this treatment is becoming of greater importance in the production of a uniform good flavor milk), homogenization should follow the vacuum flashing to preserve the full homogenization benefits attained.

Many problems were encountered during the early days of homogenization. For the most part, these have been overcome. Nevertheless, some yet prevail. These center around a) off-flavor, chiefly light-induced oxidation; b) inefficient homogenization shown by fat ring or spaghetti; and c) slack or slow bottle filling as a result of air leaks inducing foaming. Surprisingly, some yet have trouble with rancidity. This flavor defect was experienced in smaller plants where about one-third of the milk was sold as creamline milk and in one instance where the milk was vat pasteurized. Both of these situations are vulnerable to raw milk contamination which always induce rancidity in homogenized milk.

Another problem associated with homogenized milk is that of disposition of returns. As noted in Table 11, this problem was resolved in many ways, chief of which seemed to be utilization of the homogenized milk in some other dairy product. Probably, the ideal solution to the return problem, which may not always be feasible, is to permit no returns, except in damaged containers.

SUMMARY

Questionnaires concerning various phases of homogenized milk were mailed to the milk plants in Michigan.

Replies from 72 plants, processing 5,535,000 pounds of milk daily, indicated that slightly over 90 percent of the milk was homogenized. Twelve large plants, pasteurizing over 3,500,000 of milk daily, homogenized 93.4 percent of their milk.

Eighty-six percent of the plants clarified the milk, usually at a temperature around 40°F.

Sixty-four percent of the 73 plants reporting used high-temperature, short-time pasteurization of which 83 percent heated the milk to 166° to 180°F.

Generally, the milk was homogenized before H-T, S-T pasteurization and after pasteurization when the milk was vat pasteurized.

The total pressures of homogenization as well as those applied to the first and second stages varied widely. In some plants, the greater pressures were applied to the first stage and the lesser pressure to the second stage whereas the reverse was true in other plants. Twenty-five of the 41 plants using the Manton-Gaulin homogenizer (60 percent) homogenized milk at a total pressure of 2,500 p.s.i. or higher. Thirteen of the 15 (87 percent) users of the Cherry-Burrell homogenizer homogenized milk at a total pressure from 2,000 to 2,500 p.s.i. Seventy-five percent of the 12 plants using the Creamery Package homogenizer used pressures from 1,800 to 2,000 p.s.i.

The chief problems encountered with homogenized milk were sunshine flavor, fat ring, and foaming.

Where tests were made to check homogenizing efficiency, the top-and-bottom fat test method was the one most commonly used.

Returns were utilized in several ways. About one-fifth of the plants reporting permitted no returns and a like number used the returns in ice cream mix.

SURVEY OF HOMOGENIZED MILK IN MICHIGAN

II. Functions, maintenance, and care of the homogenizer with suggested sequences of operation

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THE HOMOGENIZER HAS BECOME a vital piece of equipment for milk processing in the past 25 years. The survey[1] of Michigan milk plants revealed that some 70 plants pasteurized 5,535,000 pounds of milk daily of which 90 percent was homogenized. In 12 plants alone, which pasteurized over 3,500,000 pounds of milk daily, 93.4 percent of the milk was homogenized.

The fat globules must be in the liquid, rather than in the solid state to effect fat dispersion during the homogenization process. Homogenization induces the development of bitter, rancid, soapy flavors in raw or inadequately heat-treated milk. Therefore, to insure freedom from rancidity, homogenization must be done only on the lipase-inactivated milk. In vat pasteurization, where a portion of the milk is bottled as creamline milk, homogenization must follow pasteurization.

Likewise, in systems where the pasteurized milk is vacuum-treated to remove off-flavors, (an increasingly important process in maintaining a good, uniform-flavor milk) homogenization should follow the vacuum treatment. Thus, in many installations, the homogenizer, placed through necessity after the pasteurizer, becomes a potential source of post-pasteurization contamination. Obviously, the machine must be properly sanitized to minimize bacterial contamination.

[1]Trout, G. M., C. W. Hall, and A. L. Rippen, 1961. Survey of homogenized milk in Michigan. I. The extent, operating conditions, and utilization of returns. Mich. Agr. Expt. Sta. Quart. Bul. *43*: 618-633.

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Furthermore, the daily cleaning procedure must be such that the homogenizing efficiency is not impaired while maintaining proper sanitation.

This study was made to ascertain the existing routine homogenizer cleaning and sanitizing procedures followed and to find out the present-day problems incident to the maintenance of the machine. Current variations in the sequence of homogenization were determined also in some 70 plants responding to a questionnaire through the cooperation of the Michigan Dairy Products Association.

RESULTS

In addition to doing the job for which the homogenizer was designed, that of rendering the milk a more perfect emulsion, the machine may serve also as a timing pump in high-temperature, short-time pasteurization.

The Homogenizer As a Timing Pump

Of the 47 plants employing high-temperature, short-time pasteurization, 18 (38 percent) used the homogenizer as a timing pump. Five of the 12 large plants (42 percent) used the homogenizer likewise. Apparently, therefore, the homogenizer as a timing device for H-T, S-T units was used about equally by all processors regardless of volume of milk.

Booster Pump to Homogenizer

In order to prevent starving the homogenizer and possibly suction of air, booster pumps are sometimes used to supply milk to the homogenizer. Of the 71 plants reporting, 39 (55 percent) used a booster and/or a rotary timing pump on the intake side of the homogenizer. The installations varied as to size and type of pump, placement with respect to deaeration, plates, regeneration, elevation, and so forth.

A centrifugal booster pump is often placed ahead of the homogenizer when the homogenizer is used as a timing pump. Also, the pump may be placed directly ahead of the regenerator. However, in this position the pump should be operated only when the homogenizer is in operation and when the pressure conditions in the pasteurizing unit are met. Should a booster pump not be used, care must be taken that the intake vacuum to the homogenizer should not exceed 7 in. Hg.

Servicing the Homogenizer Valve

The "valve" is the heart of the homogenizer. It must be kept in good condition if efficient homogenization is to be attained. The question was asked, "How often do you change the 'valve' on the homogenizer, if equipped with the single service 'valve'?" To this question 19 responded with data given in Table 1. Either the plants were exercising extreme care in maintaining the serviceable condition of the single-service valve, for 47 percent of them did not change them after each use, or relied on the calendar to dictate time of change. Fifty-three percent of the plants reporting changed the single-service valve each day. Forty-seven percent of the plants changed the valves weekly or less frequently, seemingly as needed, up to two years. Closer inspection of reported data showed that those with the Creamery Package homogenizer changed valves daily while those with the Cherry-Burrell machine changed them after extended periods of use or when needed. Perhaps this is in line with the manufacturer's recommendation.

TABLE 1—Frequency of valve change on homogenizers equipped with single-service "valves"

Period of valve change	Distribution of plants as to time when valves were changed	
	No.	Percent
Every day	10	52.6
Every other day	1	5.3
Weekly	4	21.1
Once per month	1	5.3
Every six months	1	5.3
Every two years	1	5.3
When needed	1	5.3
Total	19	100.2

No systematic pattern seemed to prevail in frequency of grinding the homogenizer valves. Generally, the valves were ground at three-month intervals or longer (Table 2). While some ground the valves monthly or more frequently, others never ground them at all or only as needed. Nevertheless, 21 of the 43 plants (49 percent) ground the valves once or twice a year. Again, this procedure may be in accordance with the manufacturer's recommendation.

TABLE 2—Frequency of grinding homogenizer valves

Period of grinding valve	Distribution of plants as to time of grinding homogenizer valves	
	No.	Percent
Weekly	2	4.7
Monthly	2	4.7
Every 300 hours	1	2.3
Every 3 months	1	2.3
Twice a year	12	27.9
Once a year	9	20.9
Every 2 years	2	4.7
4 to 6 years	1	2.3
Every 5 years	1	2.3
As needed	6	14.0
Never	6	14.0
Total	43	100.1

Cleaning and Maintenance

Cleaning and sanitizing the homogenizer apparently presents some problems. The majority of 76 plants reporting cleaned the homogenizer in place (Table 3). Whether cleaning manually or in place, most of the plants completely dismantled the homogenizer for cleaning at least once a week, if not daily (Table 4).

When cleaning the homogenizer in place, the machine becomes a unit or extension of the H-T, S-T cleaning-in-place system. The tension on the homogenizing valve is released after which the motor is

TABLE 3—General method of cleaning homogenizers in Michigan dairy plants

Type of cleaning	Distribution of plants as to cleaning method	
	No.	Percent
Cleaning in place	45	58.4
Manual	25	32.5
Both CIP and manual	7	9.1
Total	77	100.0

TABLE 4—Frequency of dismantling the homogenizer for cleaning

Frequency of dismantling homogenizer	Distribution of plants as to frequency of dismantling	
	No.	Percent
Daily	30	39.5
Three times a week	1	1.3
Twice a week	2	2.6
Weekly	33	43.4
Biweekly	5	6.6
Monthly	3	3.9
Trimonthly	1	1.3
Every six months	1	1.3
Total	76	99.9

started thereby placing the homogenizer into operation as a cleaning solution pump. Thus, the homogenizer must take the same solution treatment given the pipelines and the H-T, S-T plates. Data reported for 45 plants (Table 5) show that 28 (62 percent) of them definitely placed the homogenizer in circuit cleaning with the H-T, S-T pasteurizer. From specific data on time, temperature and cleaning solution sequences given on 15 of the 45 plants (33 percent) one concludes that homogenizers in these plants were tied in with CIP cleaning also.

Of particular interest in cleaning the homogenizer was the prevailing sequence of acid and alkali solutions. In 13 (87 percent) of the 15 plants on which specific data were given, the acid solution was used first then followed by the alkali solution. The machine was surged with each solution from 7 to 45 minutes at temperatures generally at 185°F. or higher.

The data indicate that in addition to this cleaning, the machine was further sanitized (Table 6). Chlorine or hot water and chlorine were the chief agents used for sanitizing the homogenizer in 62 of the 76 plants reporting (82 percent). In 10 plants (13 percent) hot water alone was used. The use of steam alone or with chlorine was not a common sanitizing method.

That the homogenizer may be a potential source of post-pasteurization contamination is reflected in the attention given to its cleaning as reported above. Moreover, the machine is generally dismantled at regular periods for further cleaning and inspection (Table 4).

TABLE 5—Specific method of cleaning homogenizers by the CIP method

Specific method of cleaning		Distribution of plants using acid-alkali treatment	
		No.	Percent
Acid-alkali (acid followed with alkali)			
Acid (time ?)	Alkali (time ?)	4	
Acid 7 min.	Alkali 7 min.	1	
Acid 45 min. at 185° F.	Alkali 45 min. at 185° F.	1	
Acid 10 min.	Alkali 10 min.	1	
Acid 30 min.	Alkali 30 min. at 190° F.	1	
Acid 5–10 min.	Alkali 5–10 min. at 165° F.	1	
Acid 30 min.	Alkali 30 min.	2	
Acid 30 min. 2%	Alkali 30 min. 0.70%	1	
Acid 30 min. at 185° F.	Alkali (time ?)	1	
		13	28.9
Alkali-acid (alkali followed with acid)			
Caustic and acid 15 min. each at 170° F.		1	
185° to 190° F. flush-acid 185°-190° F. 30 min.		1	
		2	4.4
Circuit with H-T, S-T pasteurizer		28	62.2
Special cleaning compounds		2	4.4
Total		45	99.9

TABLE 6—Sanitizing the homogenizer

Sanitizing medium	Distribution of plants as to the method of sanitizing the homogenizer	
	No.	Percent
Chlorine	46	60.5
Hot water	10	13.2
Hot water and chlorine	16	21.1
Steam	2	2.6
Steam and chlorine	1	1.3
Sanitizer	1	1.3
Total	76	100.0

Man-Hours Required for Maintenance or Repair

Considering the work done by the machine and the many hours of operation during a year, the service and repair requirements in terms of man-hours would seem to be small. Twenty-two of 71 plants (31 percent) reported spending less than five man-hours per year to maintain the homogenizer (Table 7). On the other hand, several plants used 50 hours or more during the same period to keep the machine in good condition.

TABLE 7—Distribution of plants as to man hours required to service the homogenizer

Range of man hours per past 12 months	Distribution of plants according to time required to service the homogenizer	
	No.	Percent
Less than 5	22	31.0
5 to 10	18	25.4
11 to 20	11	15.5
21 to 30	10	14.0
31 to 40	2	2.8
41 to 50	4	5.6
Over 50	4	5.6
Total	71	99.9

The Major Homogenizer Maintenance Problems Encountered

The homogenizer maintenance problems reported varied widely. These are presented as related to the specific part of the homogenizer such as:

a) *Intake valve.* A large majority of the plants had no problems associated with intake valves. Of those reporting problems, that of grinding the valves and valve seats, or reseating, was predominant. One plant reported the problem of spring breakage.

b) *Discharge valve.* Again, this unit seemed to present no special difficulty in most plants. The problems reported centered around valve grinding and breakage of springs.

c) *Lubrication.* Lubrication seemed to present no problem except that the oil had to be changed periodically. Those specifying changing oil, indicated that the oil was changed at 6 weeks, 3 months,

or twice a year. One reported lubrication after each 300 hours of operation. Some mentioned water and condensate in the oil as a problem.

d) *Motor.* Virtually no problems were associated with the motor. The reported maintenance indicated checking the bearings, motor lubrication, and tightening the belt.

e) *Pressure gauge.* For the most part, no problems were reported as being associated with the pressure gauge. Those few experiencing difficulty called attention to damage to the gauge during cleaning. Drifting, which necessitated checking the pressures against a standard gauge, was mentioned.

f) *Miscellaneous.* Several other problems of maintenance not mentioned under the above headings were given. These were:

Improper handling of plungers and parts.
Packing and gasket replacement.
Scored plungers which tore up packing and resulted in milk leakage.
Broken wire pieces from single-service valve.
Milk leakage around plungers, necessitating repacking.
Broken studs.
Replacing homogenizing valves.
Gasket or packing material on the intake strainer.
Broken safety disc seal on discharge due to starved homogenizer causing hammering (associated with air in product).

DISCUSSION

The use of the homogenizer as a timing pump in less than 50 percent of the plants using H-T, S-T pasteurization may be explained, in part, by the lack of flexibility of installations when the homogenizer is used for this purpose. Installations, employing a rotary type timing pump, have the advantage of permitting bypassing of the homogenizer when processing regular milk. With the advent of larger heat exchangers for pasteurization, a relatively high pressure drop across the plates was inevitable when suction was applied. Consequently, the use of booster pumps became necesary to keep the suction at the intake of the homogenizer below 7 in. Hg. Less trouble with air in the milk is encountered, resulting in smoother homogenizer operation, with this system.

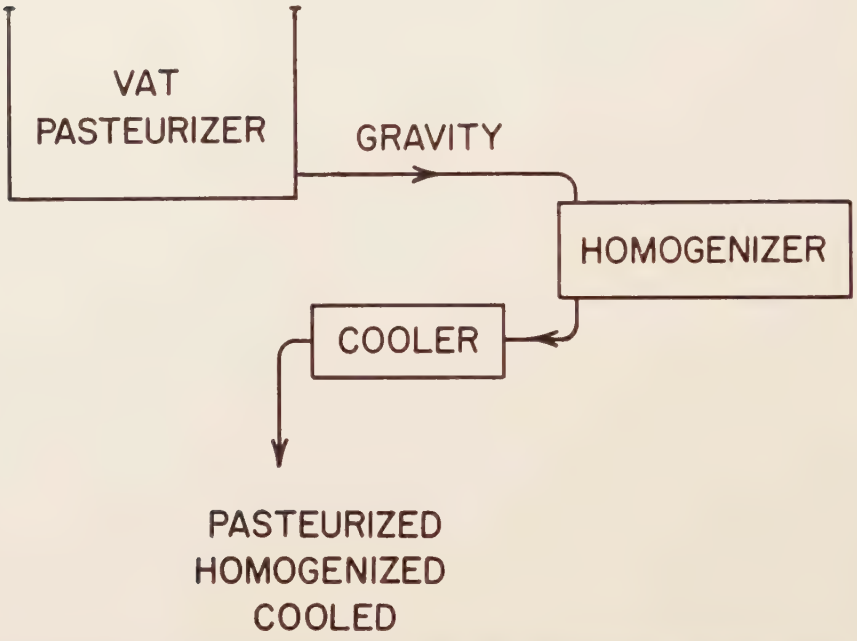


Fig. 1. Homogenization of milk after vat pasteurization (gravity flow).

Data revealed that so-called single-service valves were being used for several days' operation in a number of the plants. Perhaps this is in accord with the manufacturer's recommendation.

Cleaning of the homogenizer, especially in-place cleaning, needs to be improved and simplified. Possibly this could be accomplished through better valve, plunger, and seal designs.

Sequences of Homogenization and Pasteurization

The homogenizer may be connected to the processing system, usually with pasteurization, as the focal point of operation by one of several procedures (Figs. 1 to 7). Milk must be heated before homogenization to obtain efficient fat-globule break-up. Since inactivation of the lipase is also important, homogenization of raw milk generally is not advised. But if inadequately heat-treated raw milk is homogenized, it must be pasteurized as quickly as possible after homogenization.

The preferred method of homogenizing vat pasteurized milk is to gravity feed the milk from the vat to the homogenizer (Fig. 1). If

the installation does not permit gravity feed, a centrifugal or positive pump (Figs. 2 and 3) may be used.[2] All precautions should be taken to minimize air induction into the milk. Maintaining a pressure of 15 p.s.i. at the inlet of the homogenizer is often an effective control where suction is a problem. Piping arrangements to provide for pumps larger or smaller than the homogenizer are shown (Figs. 2 and 3).

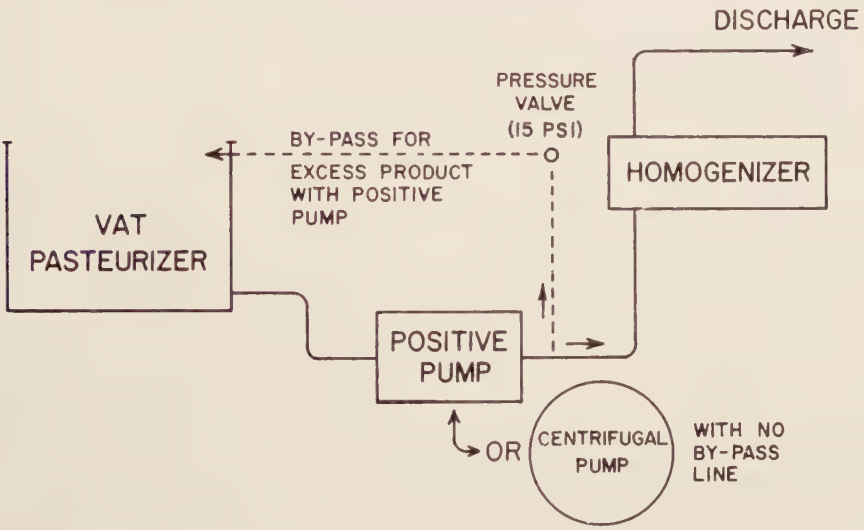

DISCHARGE
PRESSURE VALVE (15 PSI)
BY-PASS FOR EXCESS PRODUCT WITH POSITIVE PUMP
HOMOGENIZER
VAT PASTEURIZER
POSITIVE PUMP
OR
CENTRIFUGAL PUMP
WITH NO BY-PASS LINE
PUMP CAPACITY GREATER THAN HOMOGENIZER. INLET TO HOMOGENIZER AT 15 PSI TO AVOID AIR INTAKE. BY-PASS NOT NEEDED IF CENTRIFUGAL PUMP IS USED.

Fig. 2. Homogenization of milk after vat pasteurization with homogenizer above vat (positive or centrifugal pump with capacity greater than the homogenizer).

Suggested installations for H-T, S-T pasteurization and homogenization are presented in Figs. 4, 5, and 6.[3] Details of arrangements of by-pass, relief lines, equalizer, and check valves have been omitted to simplify the charts. These auxiliary components are required on some installations. For approved systems, see USPHS Milk Ordinance

[2]U. S. Department of Health, Education, and Welfare (1956). Milk Ordinance and Code. 1953 Recommendations, 3rd printing, Public Health Service Publication 229. Washington 25, D. C.

[3]Milk Industry Foundation (1957). *Manual for Milk Plant Operators.* 2nd ed. 686 pp. plus xvi illus. Washington 6, D. C.

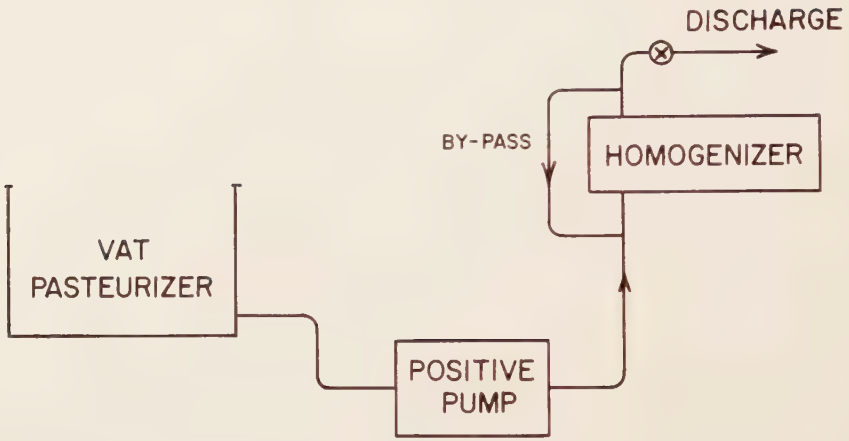


Fig. 3. Homogenization of milk after vat pasteurization with homogenizer above vat (positive pump with capacity less than homogenizer).

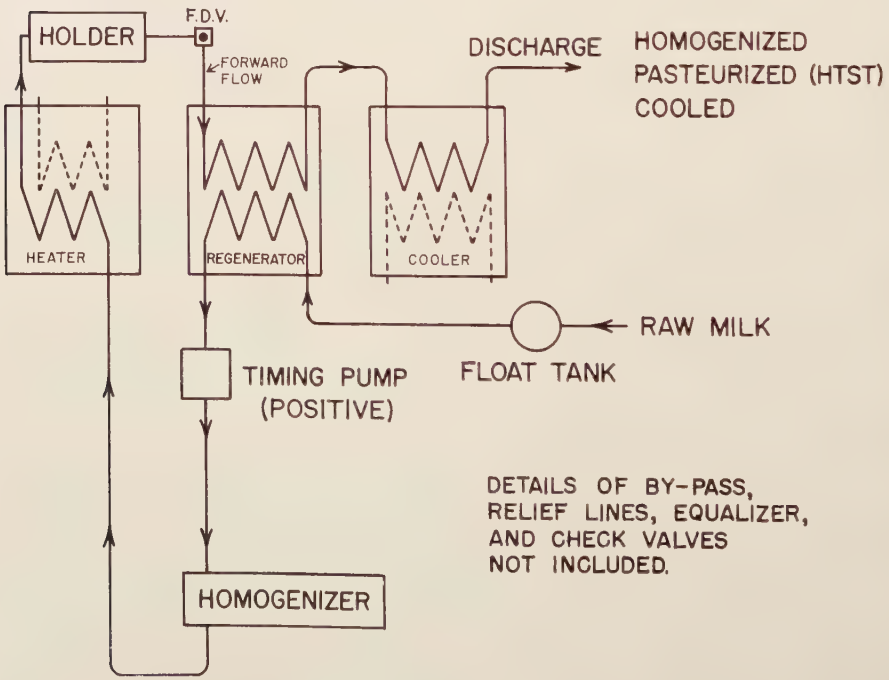


Fig. 4. Homogenization of regenerated milk before H-T, S-T pasteurization.

and Code[2] and Milk Industry Foundation Manual.[3] Homogenization is generally accomplished before pasteurization, using a positive timing pump (Fig. 4) or a booster pump with the homogenizer (Fig. 5) as the timing pump. The clarifier may be used in this circuit, but normally clarification is done before pasteurization at low temperatures (around 40°F.). The homogenization may be before or after pasteurization following heating (Fig. 6). A system for ultra high temperature and vacuum treatment is presented in Fig. 7.

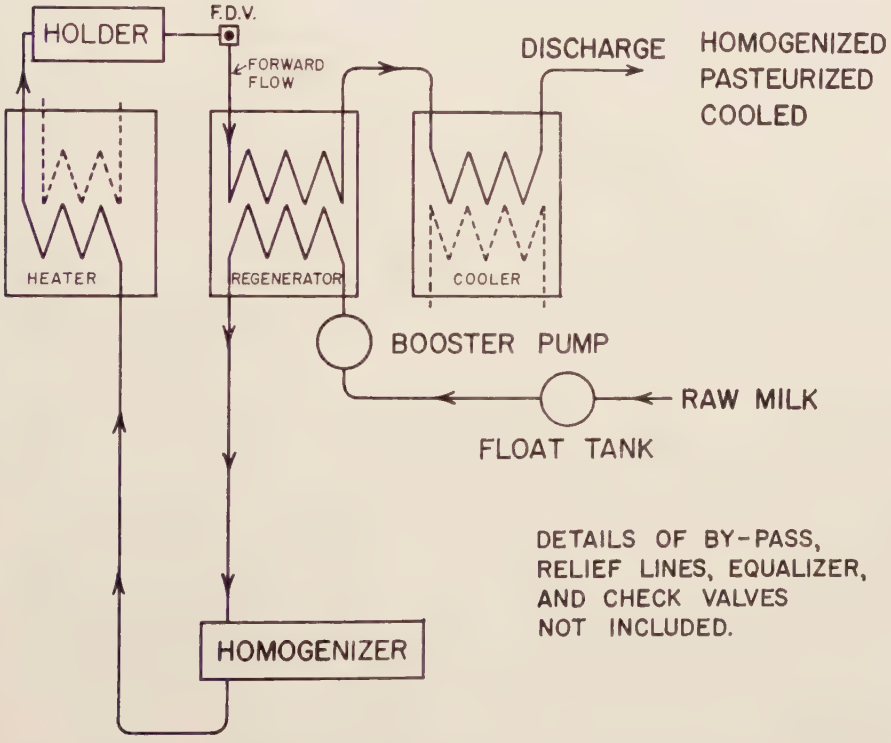


Fig. 5. Homogenizer used as a timing pump for H-T, S-T pasteurization.

SUMMARY

Virtually all milk plants in Michigan received a questionnaire covering various aspects of homogenized milk.

Replies from 72 plants, processing 5,535,000 pounds of milk daily, indicated that slightly over 90 percent of the milk was homogenized. Forty-seven of the plants employed high-temperature, short-time

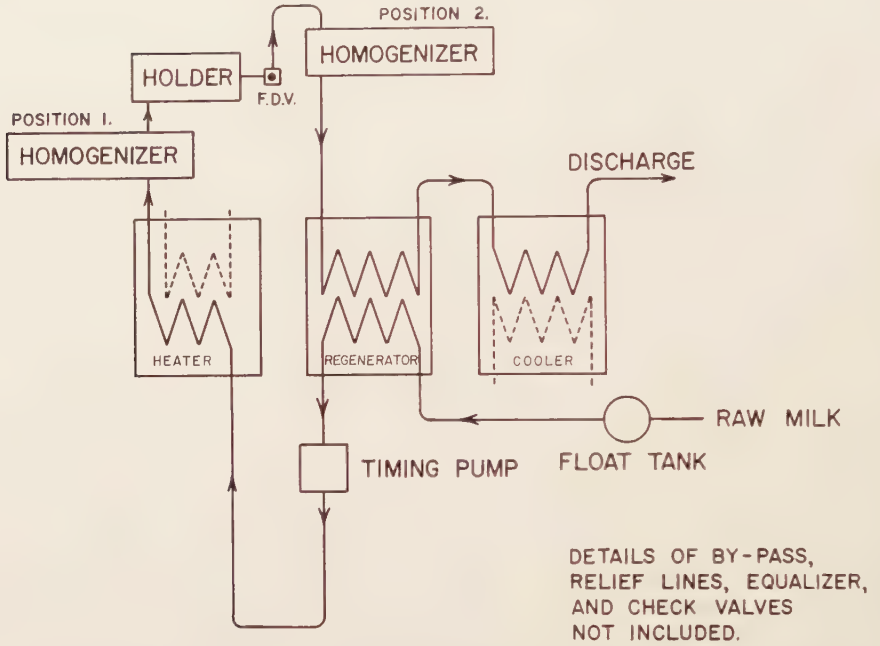


Fig. 6. Homogenization after heat treatment (before or after pasteurization).

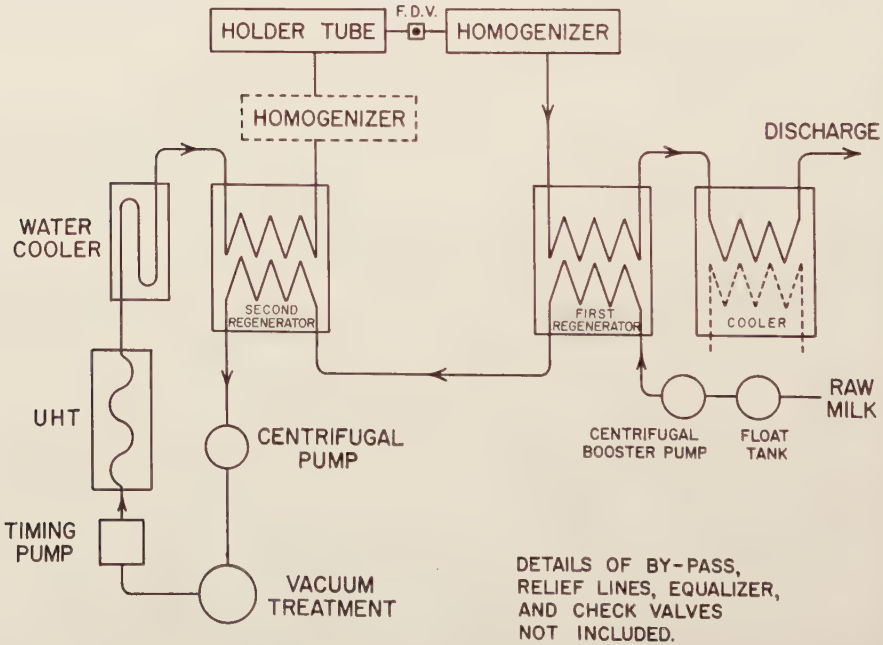


Fig. 7. Homogenization after UHT pasteurization and vacuum treatment.

pasteurization. Of these, 38 percent used the homogenizer as a timing pump for the system, often with a centrifugal pump serving as a booster.

Single service homogenizer valves apparently withstand many hours of operation. Of the 19 plants having homogenizers equipped with single-service valves, only 10 (53 percent) changed the valve every day.

Fifty-eight percent of the plants reported using the cleaning-in-place method of cleaning the homogenizer. Another 9 percent employed both in-place and manual cleaning procedures. Where high-temperature, short-time pasteurization was employed, the homogenizer received essentially the same cleaning treatment given the heat exchanger plates.

Chlorine was the sanitizing medium used in sanitizing the homogenizer in slightly over 60 percent of the 76 plants reporting. Hot water and/or hot water and chlorine combinations were used for sanitizing the homogenizer in 34 percent of the plants.

Present-day homogenizers require a relatively small amount of time for general maintenance. Valve grinding is usually done only once or twice a year in most plants.

STRAWBERRY PRICES AND MARKETING MARGINS[1]

By CARLETON C. DENNIS

Department of Agricultural Economics

Annual strawberry production in the United States has more than doubled in the years since World War II. Most of this increase has occurred in the states of Washington, Oregon and California, while production has decreased in nearly all of the formerly important strawberry producing states. Among non-Western states, Michigan is the leading strawberry producer and is one of the very few in which strawberry production increased during this period.

Michigan produces strawberries for both the fresh and processing markets. Therefore, local farm prices are available for strawberries sold for both uses. The Michigan State University Consumer Panel[2] furnished a good source of the retail prices paid for both fresh and frozen strawberries. This report concerns the prices received by producers and paid by consumers and the total marketing margin from the producer to the consumer. The analysis is limited to the years for which consumer panel data are available, 1953 through 1958. This is a small sample of years on which to base a pricing analysis, but is sufficient to indicate various pricing relationships.

Michigan strawberry production averaged approximately 34 million pounds through the years of this study, having a low of 23.4 million pounds in 1954 and a high of about 42 million pounds in 1957. In all other years, the production was between 32 and 39 million pounds. During the six years of this study, an average of 65 percent of the

[1] M.S.U. Consumer Panel Report No. 59.

[2] This report is based primarily upon data obtained through the Michigan State University Consumer Panel and includes data for 1953 through 1958. The panel consisted of a sample of about 250 families in the Lansing, Michigan area, selected as representative of residents of a city of about 100,000 population. Each week the panel families reported in an itemized diary the quantity, price and expenditure for each item purchased during the week for home consumption.

Farm production quantities and prices are taken from the annual publication, "Marketing Michigan Strawberries," Market News Service, U.S.D.A., and Michigan Department of Agriculture. Mimeo. Benton Harbor, Mich.

ARTICLE 43-69

Michigan strawberry crop was sold fresh. There was an apparent trend to place a larger percentage of the crop in the fresh market, with 58 percent sold fresh in 1953 and 81 percent sold fresh in 1958.

Producer Prices[3]

While Michigan strawberry production has fluctuated considerably, prices received by producers have fluctuated even more drastically. Processing strawberries, for instance, brought an average price of only 8.7 cents per pound in 1957, while in 1954 this average was 17.9 cents. Fresh strawberry prices were somewhat less variable, having a low of 13.3 cents in 1957 and a high of 19.8 cents in 1954.

Panels A1 and A2 of Fig. 1 show the Michigan producer price-quantity relationships for fresh and frozen strawberries in the years of 1953-58. Panels B1 and B2 show this for California producers, and panels C1 and C2 show this for the average of all United States producers. An average regression line is shown in several of the panels.[4] The closeness of annual price-quantity observations to the regression line indicates how much influence local production has on local farm price.

Consider, first, the fresh strawberry panels (A1, B1, C1) of Fig. 1. It is apparent that in Michigan (A1) the producers' fresh strawberry price is not well determined by the quantity sold by Michigan producers. Next, consider California (B1). The closeness of individual observations to the regression line indicates that the amount of fresh strawberries sold by California producers has a very important influence on price received.

The primary reason for the better "fit" of annual price-quantity observations to the regression line for California than for Michigan is the larger quantity produced. California, with roughly half of the

[3] All prices given in this report are adjusted to the 1947-49 price level.

[4] Regression equations, adjusted correlation coefficients (squared), and standard errors of the estimates for regression lines shown in Fig. 1 are as follows:

Panel

A1. $Y_M = 24.16 - .321\ X_M$; $R^2 = .50$; $S = 1.98$.

B1. $Y_C = 31.12 - .139\ X_C$; $R^2 = .89$; $S = 1.29$.

C1. $Y_{U.S.(f)} = 35.08 - .0685 X_{U.S.(f)}$; $R^2 = .96$; $S = .53$.

C2. $U_{U.S.(p)} = 21..52 - .279 X_{U.S.(p)}$; $R^2 = .31$; $S = 2.33$.

Y_M is the Michigan fresh market strawberry price.
Y_C is the California fresh market strawberry price.
$Y_{U.S.(f)}$ is the United States fresh market strawberry price.
$Y_{U.S.(p)}$ is the United States processing strawberry price.
(All prices are in cents per pound of raw product.)
X_M, X_C, and $X_{U.S.(f)}$ are Michigan, California, and total United States production for the fresh market in 1,000 pounds.
$X_{U.S.(p)}$ is total United States production for the processing market plus May 1 cold storage stocks, in 1,000 pounds.
Regression lines are not given in panels A2 and B2 of Fig. 1 because of lack of correlation between average annual price and annual production for processing in these cases.

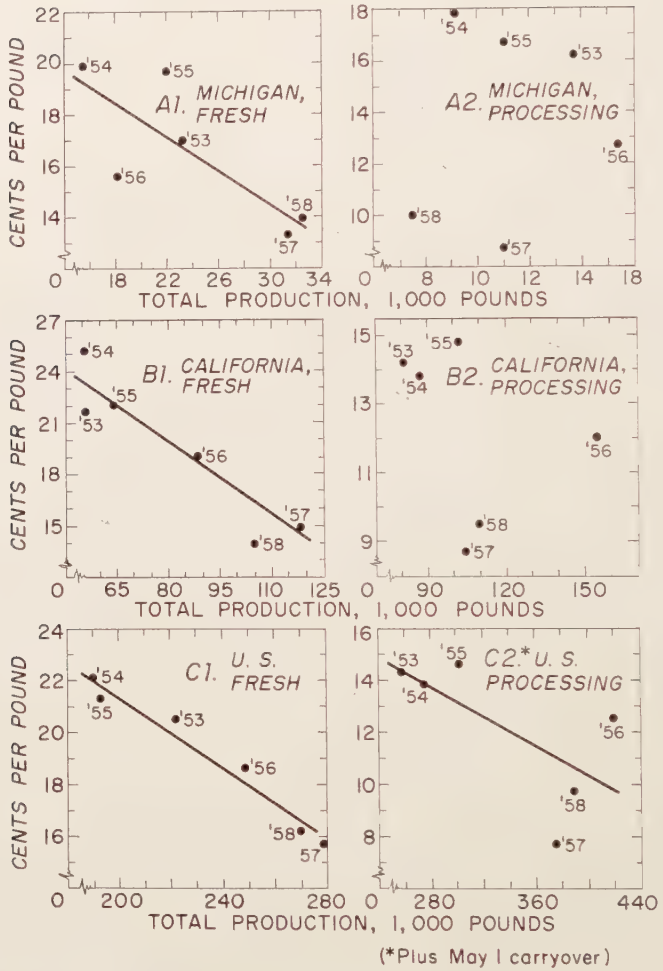


Fig. 1. Fresh and processing strawberry farm level price[a]-quantity relationships in Michigan, California and the United States.

[a]All prices adjusted to 1947-49 price level.

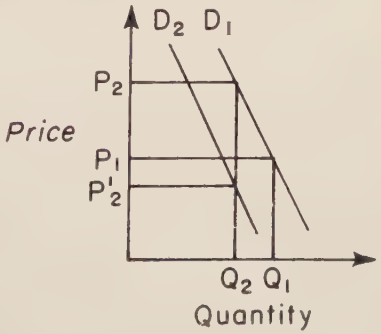
nation's fresh strawberry production, is a much stronger force in the determination of market price than is Michigan, which produces about 5 percent of the fresh market strawberries in the United States. Even though most of the Michigan strawberries are not sold in direct competition with California strawberries, the quantity of strawberries produced in California has a considerable influence on Michigan strawberry price.

The good "fit" of the regression line to annual United States average prices (C1) indicates that, on the national level, fresh strawberry price is well determined by quantity produced. It shows that while local production decisions have a comparatively weak price effect, national production decisions have a strong price effect.

The price-quantity relationship is not as well defined for processing strawberries as for fresh strawberries. Michigan and California production for processing, taken individually, have very little influence on local price (panels A2 and B2). In panel C2, where the relationship of annual average United States price and total United States production plus carryover on May 30 is shown, a somewhat better, but still not good, correlation is indicated. This may mean that the pricing mechanism is working somewhat better for fresh than for processing strawberries. However, the lack of correlation is believed due to (1) the influence of fresh strawberry price on processing strawberry price (at the farm level), (2) a decreasing demand over time for frozen strawberries, and (3) a very inelastic frozen strawberry demand.[5]

Figure 2 gives the relationship of Michigan producer prices to average United States producer prices. If the prices received by Michigan producers were equal to the United States average prices, the observations would be exactly on the line which goes through the figure. Michigan prices higher than United States prices are shown by observations above the line, lower Michigan prices by observations below the line. This figure shows that Michgan producers have consistently received below average prices for fresh strawberries, but that they received higher than average prices for processing strawberries in each of the six years of the study—much higher in the first three years.

Producers generally receive from 3 to 4 cents more per pound for fresh than for processing strawberries. This is shown in Fig. 3, where processing strawberry prices are given on the vertical axis and fresh strawberry prices are given on the horizontal axis. The "fit" of annual



[5] An inelastic and shifting demand can make an analysis of price-quantity relationships using annual observations difficult if not impossible. This is because a small shift in demand can "cover up" the price-quantity relationship. For instance, in the accompanying figure, D_1 is demand in year No. 1 and D_2 is demand in year No. 2. Q_1 and P_1 represent actual quantity and price in year No. 1. If quantity decreased to Q_2 in year No. 2, we would expect price to increase to P_2. If, however, demand has shifted to D_2, price will be at P_2 and we have the "hard-to-explain" situation of both decreasing price and decreasing quantity.

observations to the regression line[6] indicates that prices are set for strawberries sold in each outlet on the basis of total strawberries available for both outlets. There is evidently a rather consistent pricing differential, with the spread narrowed slightly in years of high strawberry prices (or in years of low strawberry production).

Consumer Prices[7]

While the annual average purchases of fresh strawberries are fairly well correlated with the annual average prices paid for this product, the weekly prices and purchases show little relationship. Figure 4

[6] The regression equation is
$Y = -7.9428 + 1.3077X$; $\bar{R}^2 = .90$; $S = 1.18$.
Y is the Michigan producer price for processing strawberries.
X is the Michigan producer price for fresh market strawberries.

[7] All prices given in this report are adjusted to the 1947-49 price level.

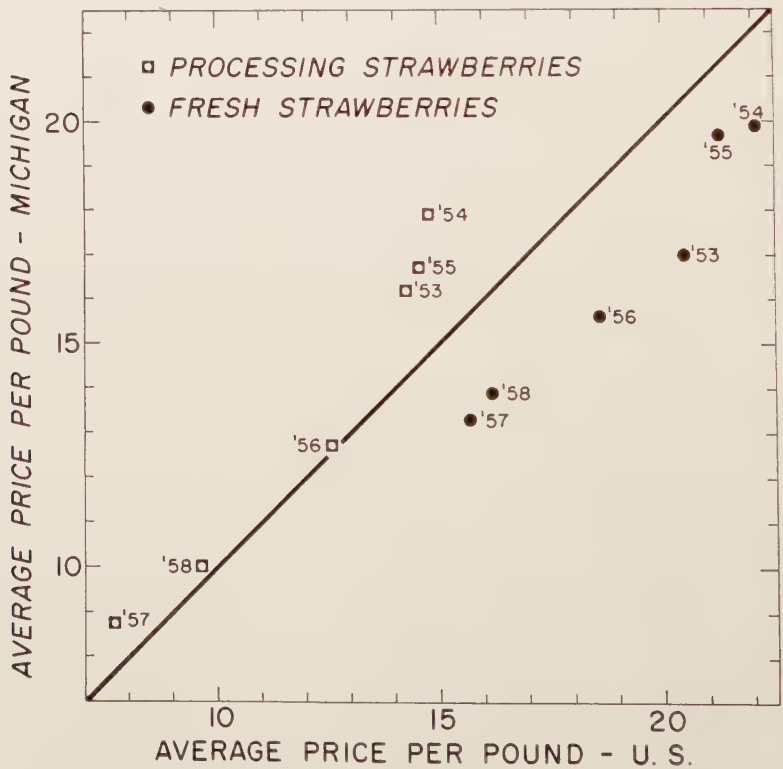


Fig. 2. Relationship of average prices[a] received by Michigan producers to average prices[a] received by all United States producers for fresh market and processing strawberries, 1953-59.

[a]Prices adjusted to 1947-49 price level.

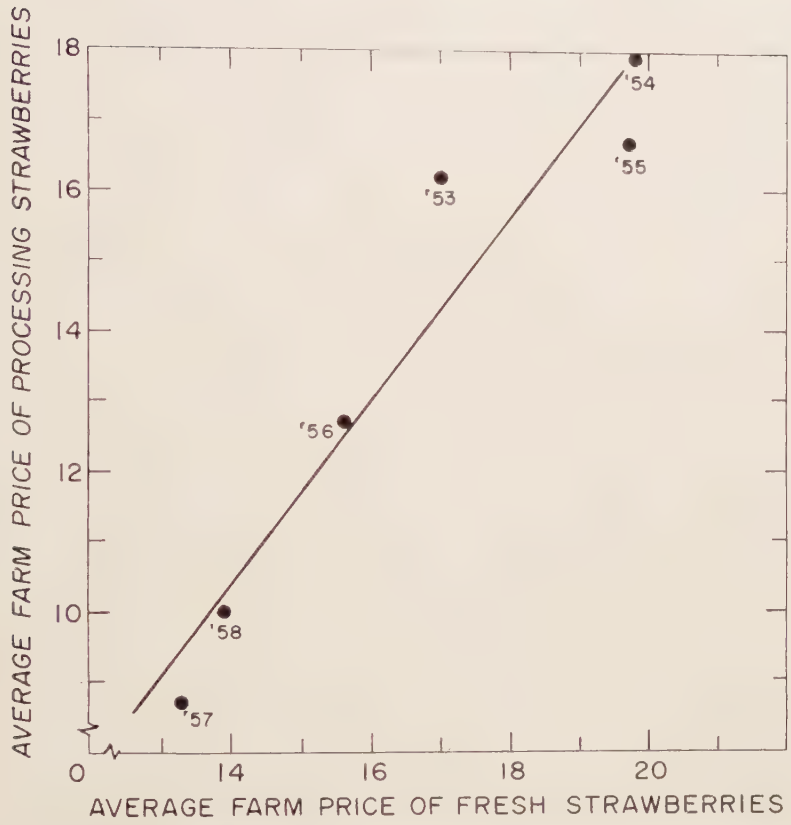


Fig. 3. Relationship of Michigan farm prices paid (adjusted to 1947-49 price level) for fresh market and processing strawberries.

shows the average weekly per capita purchases of fresh strawberries with average weekly prices superimposed. Purchases and prices are shown only for weeks in which an average of at least .005 pound per capita was purchased. The weeks of largest purchase, of course, occur during the peak of the local strawberry harvest, and few fresh strawberries were purchased during weeks completely outside the time of local harvest.

Frozen strawberry purchases and prices are poorly correlated when given on either weekly or annual bases. Average weekly frozen strawberry prices and per capita purchases are shown in Fig. 5. Frozen strawberry purchases were greatest between the 10th and 20th weeks of the year and reached a high in the 16th week. Purchases

declined after the 20th week and did not recover until the early weeks of the following year. This was a rather consistent annual purchase pattern.

Frozen strawberry prices, on the other hand, were quite stable throughout the year. They are shown in Fig. 5 to be lowest in the summer, reaching a low point in the 35th week and then rising somewhat in following weeks. This is an expected price pattern, since storage costs increase with time and should be reflected in consumer price.

When fresh strawberry purchases and prices are placed on an annual basis, a somewhat better correlation results.[8] In Fig. 6, panel A, annual per capita purchases of fresh strawberries are plotted against average annual retail prices. The regression line drawn through

[8] A regression of fresh strawberry price on quantity yields the following equation.
$Y = 45.79 - 5.14X$; $R^2 = .77$; $S = 2.06$.
Y = price of fresh strawberries in cents per pound.
X = annual per capita purchases of fresh strawberries in pounds.

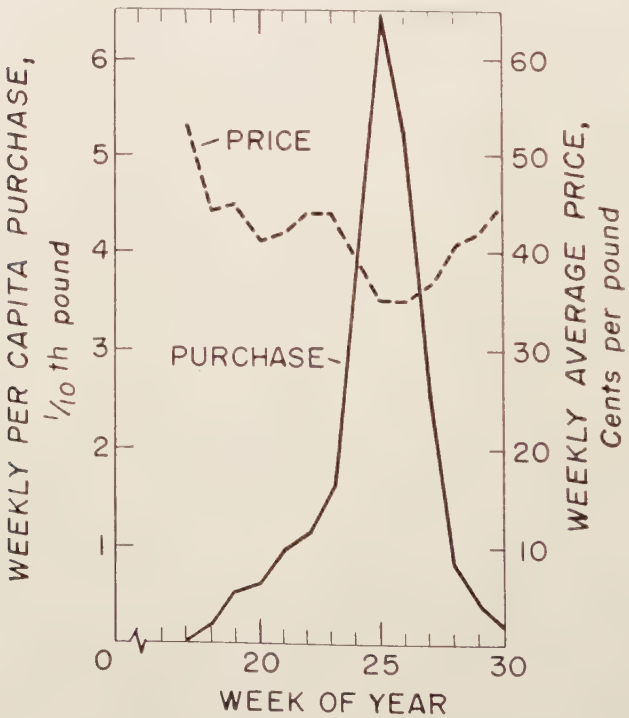


Fig. 4. Average weekly per capita purchases and prices paid (adjusted to 1947-49 price level) for fresh strawberries, M.S.U. Consumer Panel, Lansing, Michigan, 1953-58.

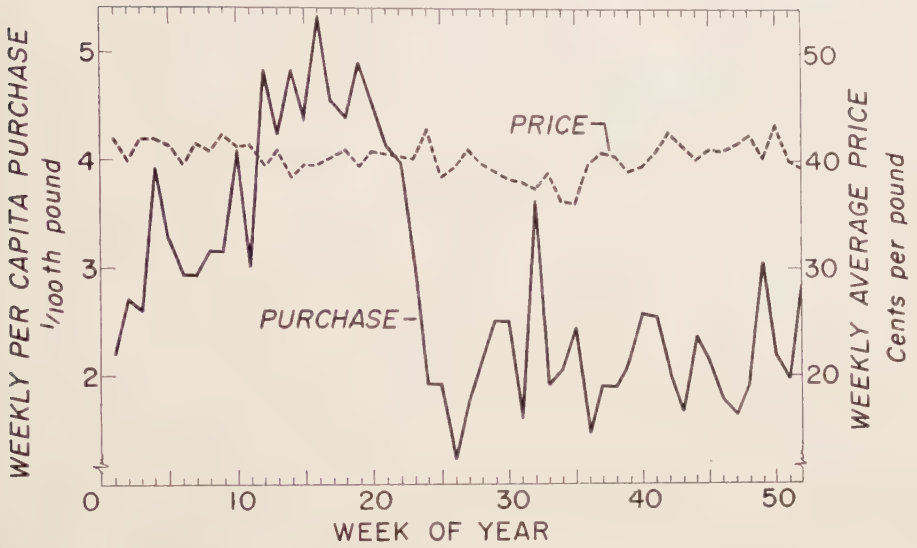


Fig. 5. Average weekly per capita purchases and prices paid (adjusted to 1947-49 price level) for frozen strawberries, M.S.U. Consumer Panel, Lansing, Michigan, 1953-58.

these observations gives the average relationship between retail price and per capita purchases.

Similar observations are plotted for annual per capita frozen strawberry purchases and average retail prices in panel B of Fig. 6. There is practically no correlation between these variables,[9] probably due to a decreasing demand over time. Nearly equal quantities were purchased in '53, '54, '56 and '58 but at widely differing prices which generally decreased with time. A larger quantity was purchased in '55 than in either '56 or '58, but of these three years the price was highest in '55. Also, a greater per capita quantity was purchased at a higher price in '57 than in '58. Since decreasing purchases of a given food item are usually associated with increasing prices, the only logical explanation is a decreasing demand which overshadowed the price-quantity relationship.

Figure 7 shows the relationship of fresh and frozen strawberry prices at the retail level. With the exception of 1953, there was a rather consistent relationship between retail prices of fresh and frozen strawberries. This, of course, follows from the farm level price relationship of fresh and processing strawberries (Fig. 3).

[9] A regression of price on per capita quantity gives the following relationship:
$Y = 46.58 - 8.35X$; $\bar{R}^2 = .18$; $S = 4.97$
Y = price of frozen strawberries in cents per pound.
X = annual per capita purchases of frozen strawberries in pounds.

Marketing Margins

The difference between the price the producer receives for his product and the price the consumer pays is defined here as the total marketing margin. This may include costs of processing (including waste), transportation, containers, selling and profit. Figure 8 shows the retail price, producer price, and marketing margin for fresh (panel A) and frozen (panel B) strawberries. The margins, especially for fresh strawberries, are shown to be more stable than either producer or retail prices.

Statistical analysis of the marketing margins indicates that the retail price is the best indicator of the amount of the margin.[10] Fresh

[10] It should be recognized that a high degree of correlation between marketing margin and retail price is to be expected since marketing margin accounts for approximately 50 percent of the retail price.

The regression of fresh strawberry marketing margins on retail prices yields the following results:

$Y = 4.07 + .36X$; $\bar{R}^2 = .80$; $S = .74$

Y = fresh strawberry marketing margins in cents per pound.
X = fresh strawberry retail price in cents per pound.

Regressions of frozen strawberry marketing margins on retail prices yield the following results:

1. With margins expressed as cents per pound

$Y = 12.59 + .21\ X$; $\bar{R}^2 = .35$; $S = 1.07$

Y = frozen strawberry marketing margin in cents per pound
X = frozen strawberry retail price in cents per pound.

2. With margins expressed as a percentage of retail price

$Y = 99.70 - 1.21X$; $\bar{R}^2 = .70$; $S = 3.43$

Y = frozen strawberry marketing margin as a percentage of retail price.
X = frozen strawberry retail price in cents per pound.

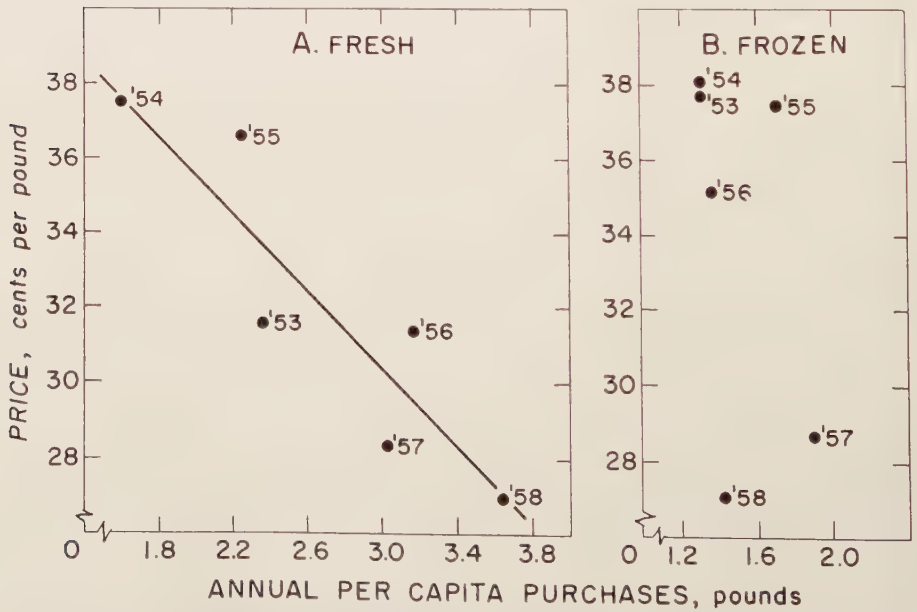


Fig. 6. Relationship of retail prices (adjusted to 1947-49 price level) and per capita purchases of fresh and frozen strawberries, M.S.U. Consumer Panel, Lansing, Michigan, 1953-58.

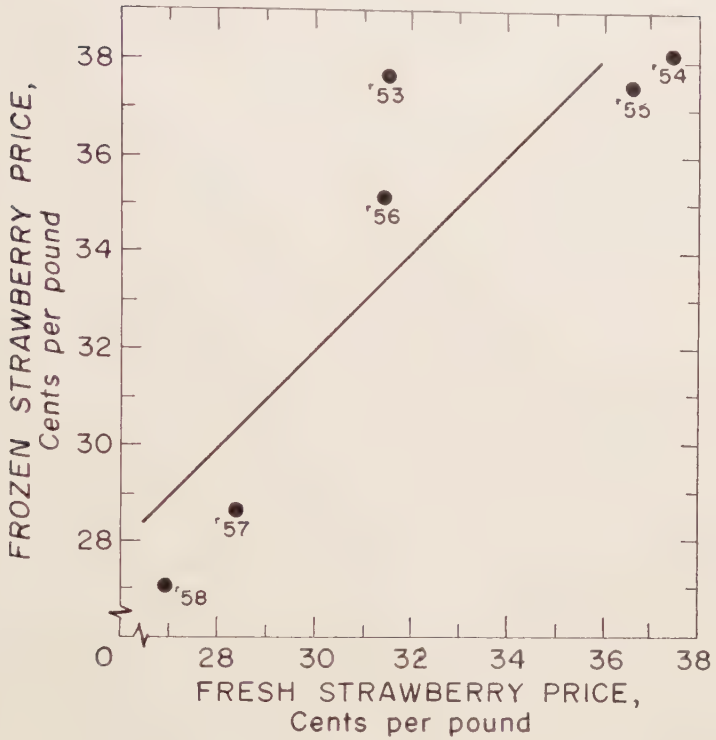


Fig. 7. Relationship of M.S.U. Consumer Panel prices paid (adjusted to 1947-49 price level) for fresh and frozen strawberries.

strawberry margins averaged about 4.07 cents per pound plus 36 percent of retail price. This would mean that at a retail price of 30 cents the total margin would be 4.07 plus 10.8 or 14.87 cents and the farm price would be slightly more than 15 cents (30—14.87).

Frozen strawberry marketing margins, when similarly analyzed, were found to average 12.59 cents plus 21 percent of retail price. However, best results were obtained by analysis of the margin strictly as a percentage of the retail price. When considered on the basis of retail price, the frozen strawberry percentage margin averaged 99.70 minus 1.21 times the retail price. The margin as a percent of the retail price decreased as retail price increased. For instance, if the retail price were 30 cents, the percentage margin would be estimated at 99.70 minus 36.30 or about 63.4 percent of the retail price. Thus, the margin would be about 19 cents and the producer would receive about 11 cents.

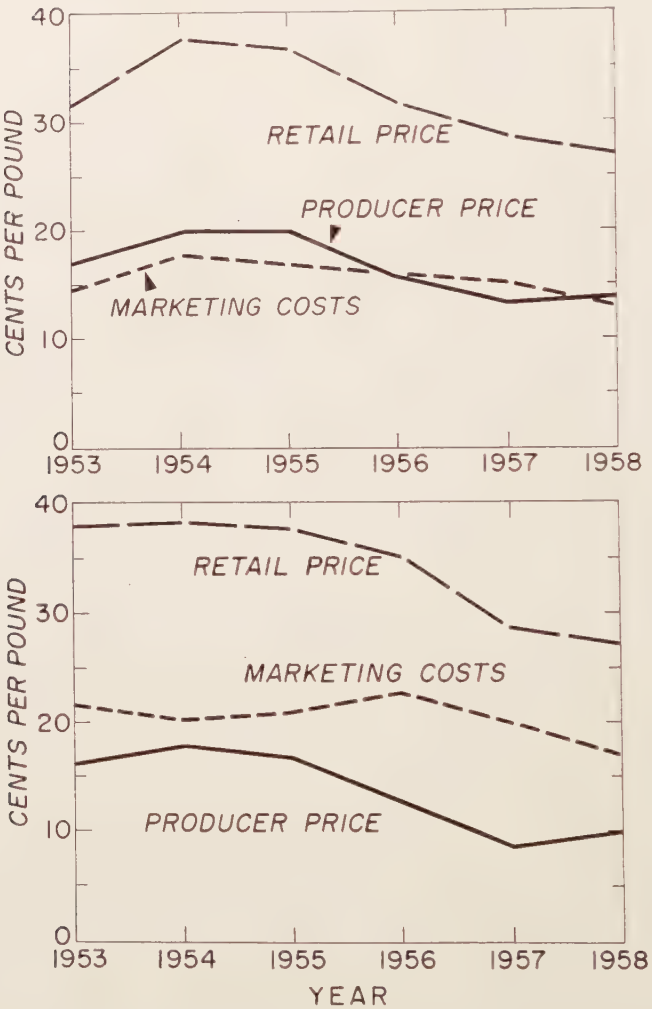


Fig. 8. Retail price, producer price, and marketing costs for fresh (upper chart) and frozen (lower chart) strawberries.

Sources of data: Retail prices from M.S.U. Consumer Panel. Producer prices from Marketing Michigan Strawberries (1954-59 seasons). (All prices adjusted to 1947-49 price level).

CONCLUSION

The production of strawberries for both the fresh and frozen markets has fluctuated considerably in recent years. The prices received by Michigan producers and paid by consumers have also fluctuated greatly but not in a manner consistent with production

changes. This is at least in part due to the fact that strawberry prices are determined in a national market in which Michigan represents only a minor share of the total supply.

The processing strawberry outlet represents more than half of total strawberry consumption, yet the farm level price-quantity relationship for processing strawberries is not as well defined as for fresh strawberries. This suggests that fresh market strawberry prices are well determined by the quantities of strawberries offered for that use, but processing strawberry prices seem to be set to a large extent by fresh strawberry conditions. This is indicated by the much better correlation of processing strawberry price with either fresh strawberry price or quantity than with processing strawberry quantity.

Most of the United States strawberries are produced in the three west coast states. It would normally be expected that the producing areas nearest the consuming market would have a greater comparative advantage in production of fresh than in production of processing strawberries because of the perishability of the fresh product. However, comparison of Michigan and average United States prices shows that Michigan producers received higher prices for processing and lower prices for fresh strawberries than the United States average in each of the six years of this study.

Marketing margins—the difference between farm and retail prices —are fairly stable. Statistical analysis of the marketing margins for fresh and frozen strawberries revealed that they are best "explained" by the retail price. Marketing margins in general increase or decrease less than retail price but in percentage terms account for a greater share of the retail price at low than at high prices. This, of course, means that the producer's share of the retail price increases as price increases and as retail price decreases the producer obtains a smaller percentage of a smaller total.

JOURNAL ARTICLE ABSTRACTS

Research Problems on the Occupational Achievement Levels of Farm-Reared People

HALLER, A. O.

Rural Soc. 23(4):356-362. 1958. (Journal Article 2147 from the Michigan Agricultural Experiment Station)

Research has shown that farm-reared people have low levels of occupational achievement in the nonfarm world. Lipset has tried to explain this by pointing to the effect of limited occupational and educational alternatives (supposedly characterizing rural life) on levels of occupational and educational aspiration. In turn, Lipset hypothesizes that levels of occupational and educational aspiration account for levels of occupational achievement. The present paper summarizes the researchable assumption of Lipset's explanation, reviews data testing several aspects of the explanation, presents new data testing other aspects of the explanation, and presents a test of an alternative to one element of the explanation. The explanation is found to be only partially correct. It is valid in that levels of occupational achievement are correlated with levels of educational and occupational aspiration. It is invalid in that farm nonfarm differences in levels of educational aspiration are not large enough to explain much of variation in levels of occupational achievement, and it is invalid in that farm plans are found to explain all of the apparent relationships of farm residence to levels of occupational aspiration.

Bovine Malignant Catarrhal Fever in Michigan II. Pathology

BERKMAN, R. N.; R. D. BARNER; C. C. MORRILL AND R. F. LANGHAM

Amer. Jour. of Vet. Res. 21(85):1015-1027. 1960. (Journal Article 2271 from the Michigan Agricultural Experiment Station)

The gross lesions of malignant catarrhal fever generally found were poor condition, nasal and ocular discharge, corneal opacity, erosions of the muzzle and oral cavity, erythema of the udder and vulva, thickening and cracking of the epitelium of the teats, and, occasionally, encrusting of the skin and tufting of the hair. The lymph nodes were usually enlarged, edematous and congested. Diphteritic membranes were usually present in the nasal passages, pharynx and trachea. Congestion and, more rarely, hemorrhage and erosion were observed in the digestive tract. In some cases hemorrhage and erosion were found in the urinary bladder.

Microscopically, proliferative and infiltrative lesions were variably observed in most organs. Lesions were constantly present and marked in the liver and brain; these were of important diagnostic significance.

The Effect of Various Sugars on the Formation and Character of Gluten

Meiske, Donna Poland; Mary Frang Jones and Evelyn M. Jones

Cereal Chemistry. 37(4):483-488. 1960. (Journal Article 2303 from the Michigan Agricultural Experiment Station)

The effect of low concentrations of various sugars was studied in gluten balls baked from gluten prepared in three ways: (1) a flour-water-sugar dough, (2) a flour-water-sugar dough with the corresponding sugar again added to the gluten after working, and (3) a flour-water dough with sugar added to the gluten after working. In general, sugars caused decreased volumes. The effect was least in method one and greatest in method two. Tenderness was increased signficantly only in method two. Sugars apparently exerted a dehydrating effect when added to raw gluten as shown by extent of drip loss.

When various sugars were added independently to flour-water doughs at 5 per cent increments, they prevented gluten formation at levels from 30 to 65 per cent, except the relatively insoluble D (+) lactose.

Planning to Farm: A Social Psychological Interpretation

Haller, A. O.

Social Forces. 37(3):263-268. 1959. (Journal Article 2308 from the Michigan Agricultural Experiment Station)

Social psychological theory regards planning to farm as an early stage of the total act of entering farming. Similarly, from abstract theory it can be deduced that planning not to farm is an early phase of the act of leaving the farm world to enter the nonfarm world. If this is true, it may be hypothesized that the latter act requires social and psychological support just as entering farming does (shown by previous research). Ten factors possibly supporting nonfarming are tested for association with planning not to farm. Seven of the tests tend to confirm the hypothesis; three tend to reject it. Overall, it is concluded that this hypothesis is tenable.

Some Factors Affecting the Dispersibility of Whole Egg Solids in Water

Miller, G. A.; E. M. Jones and P. J. Aldrich

Food Research 24(5):579-583. 1959. (Journal Article 2324 from the Michigan Agricultural Experiment Station)

Effect of water temperature, mixing method, and the presence of dry sucrose on optimum dispersibility in the rehydration of spray-dried whole egg solids has been investigated. In Series A five water temperatures and four mixing methods were studied. In Series B three concentrations of sucrose with the egg solids were dry-blended before the addition of water. Two mixing methods, and three temperatures of water were used. Rehydrated samples for both series were strained and the undispersed solids were determined.

Three out of 4 mixing methods resulted in increased dispersibility, significant at the 1% probability level, in combination with water ranging from 21 to 45° C. Dispersibility was not significantly affected by sucrose or by the aeration of the solids prior to the addition of water.

A Comparison of the Gelation Properties and Palatability of Shell Eggs, Frozen Whole Eggs, and Whole Egg Solids in Standard Baked Custard

MILLER, G. A.; E. M. JONES AND P. J. ALDRICH

Food Research 24(5):584-594. 1959. (Journal Article 2325 from the Michigan Agricultural Experiment Station)

The gelation properties and palatability of shell eggs, homogenized frozen eggs, blended frozen eggs, and reconstituted spray-dried whole egg solids in standard custard baked to 86, 88 and 90°C. were compared.

Dried egg custards baked to 86, 88 and 90°C. were not comparable in firmness (penetration, curd tension, percentage sag) to shell and frozen egg custards containing equivalent egg solids.

Subjective evaluations for palatability indicated dried egg custards were significantly different from and were scored lower than shell or frozen egg custards in this study.

Peer Influences on Levels of Occupational and Educational Aspiration

HALLER, A. O. AND C. E. BUTTERWORTH

Social Forces. 38(4):289-295. 1960. (Journal Article 2345 from the Michigan Agricultural Experiment Station)

Previous reserch shows that levels of occupational and educational aspiration have an important correlation with levels of achievement in later life. Less evidence is available on the factors producing differential levels of aspiration.

However, experiments in social psychology have shown that people who interact with each other tend to develop similar ways of looking at their place in society. The present study uses field data (all 17 year old boys in school in Lenawee County in the Spring of 1957) to show that the above experimental findings apply also to levels of occupational and educational aspiration.

The study thus identifies a new group, the peer group, which probably is a partial determiner of the degree to which youth are successful in later life.

Practical Implications of Nutrient Losses from Plant Foliage by Leaching

TUKEY, H. B. AND H. B. TUKEY, JR.

Amer. Soc. for Hort. Sci. 74:671-676. 1959. (Journal Article 2381 from the Michigan Agricultural Experiment Station)

The removal of nutrients from above-ground parts of plants by leaching has been conclusively demonstrated. Among the practical implications related to such losses are:

a) choice of time and techniques employed in the sampling of leaves for analysis,

b) differences in nutrient composition between greenhouse- and field-grown crops,

c) rooting of cuttings under mist,

d) relation of foliar leaching to choice and performance of greenhouse-grown crops,

e) effect of syringing, spraying, and overhead irrigation,

f) susceptibility to insect and disease attack and to the appearance of certain physiological disorders through an altered plant nutrient content.

g) effect upon quality and nutritive value of fruit, grain, and foliage crops,
h) building of soil and maintenance of soil fertility, and
i) adaptation, distribution, and succession of plants in their native environment.

The Use of Carbon Electrodes in High Voltage AC Arc Excitation

Connor, Jane and Samuel T. Bass

Applied Spectroscopy. 14(2):55-56. 1960. (Journal Article 2420 from the Michigan Agricultural Experiment Station)

A comparison of various combinations of carbon and graphite electrodes was made to determine the most suitable electrode geometry in the spectrochemical analysis of graphite-potassium sulphate buffered samples in the high voltage AC arc. It was found that a flat carbon counter electrode combined with a graphite sample-holding gave more acceptable precision and sensitivity combined with ease of preparation than the other combinations tested.

Selecting for Yield and Sucrose Improvement in a Monogerm Sugar Beet Variety

Hogaboam, George J.; F. W. Snyder and H. W. Bockstahler

Proc. of Amer. Soc. of Sugar Beet Technologists, Tenth Regional Meeting. 1959. (Journal Article 2425 from the Michigan Agricultural Experiment Station)

Details of the selection and breeding techniques, used to improve the yield and sucrose content of the monogerm sugar beet variety SP 5832-0, are presented.

Property Taxes and Alternatives for Michigan

James, Lee M.

Jour. of Forestry 58(2):86-92. 1960. (Journal Article 2429 from the Michigan Agricultural Experiment Station)

The general property tax has long been considered a major problem by those concerned with forestry. Present problems in forest property taxation include: (1) a penalty inherent in annual tax payments on deferred-yield forests; (2) inequitable assessments among forest properties in relation to each other and to other kinds of properties; (3) theoretical errors in adding land values to timber values; and (4) frequent valuations which far exceed value based on sustained earning power.

Optional yield tax laws available in Michigan offer theoretically superior alternatives to the general property tax for the forest landowner. However, the specific provisions of these laws raise serious questions from the point of view of both landowner and taxing unit of government. Several new approaches within the framework of the property tax are described; these hold much promise for improvements in forest taxation.

An Ecological Study of the Winter Range of Elk and Mule Deer in the Rocky Mountain National Park

GYSEL, LESLIE W.

Jour. of Forestry. 58(9):696-703. 1960. (Journal Article 2437 from the Michigan Agricultural Experiment Station)

This study is based on an analyses of plant growth in exclosures erected 25 years previous to measurements and observations made in 1958 and on numerous observations made by park technicians.

The cover of shrubs or trees was generally much greater inside the exclosures than on the open range. Grasses and forbs decreased in the exclosures.

Most of the differences resulting from the protection of the exclosures were apparently due to the browsing of mule deer; elk in the park exist primarily on grasses and some forbs during the winter. The number of deer in the park will probably be an important factor in maintaining the present grass-forb cover.

Changes in the beauty of the landscape are discussed.

Vibrator, A Recessive Sex-Linked Mutation in Broad Breasted Bronze Turkeys

COLEMAN, T. H.; R. K. RINGER; W. J. MATHEY; K. C. ROOD AND C. W. POPE

Jour. of Heredity 50(4):158-160. 1960. (Journal Article 2465 from the Michigan Agricultural Experiment Station)

Three of the Broad Breasted Bronze poults hatched at the Michigan Agricultural Experiment Station in 1956 exhibited a very rapid shaking, or vibration, of the head and neck. Many of the poults hatched in 1957 showed the condition. An analysis of the 1957 hatching records pointed to the action of a single sex-linked recessive gene as being responsible for the vibrating condition. "Vibrators" and normals were mated in all possible combinations during the 1958 hatching season. Results of these matings proved rather conclusively that the "vibrator" condition is caused by a single sex-linked recessive gene. The symbol *vi* is suggested for this character.

Estimation of Thyroid Secretion Rate of Rainbow Trout Using Radioactive Iodine

HOFFERT, JACK R. AND P. O. FROMM

Jour. of Cellular and Comparative Physiology. 54:163-169. 1959. (Journal Article 2468 from the Michigan Agricultural Experiment Station)

Since the pattern of iodine metabolism of the teleostean thyroid is similar to that of higher vertebrates, thyroid secretion rates (TSR) of trout were determined using a technique which has been successfully applied to warm-blooded animals. The mean thyroid secretion rates (TSR) for yearling trout kept at 13° to 3°C. were 0.244 and 0.139 ug. 1-thyroxine 100gm. day respectively. No significant differences in TSR occurred between yearling and 2-year-old trout kept at 13°C. TSR of fish at 3°C. were significantly lower than values for 2-year-old fish and 1-year-old fish kept at 13°C. Q_{10} values of 2.17, 1.97 and 1.75 for oxygen consumption, opercular rate and TSR respectively, were calculated from mean values obtained at 3° and 13°C. It was concluded that the thyroid of trout has little or no influence on the oxidative metabolism at low temperature, and it appears doubtful that the trout thyroid is involved in a temperature compensating mechanism as has been postulated.

The Occupational Achievement Process of Farm-Reared Youth in Urban-Industrial Societies

HALLER, A. O.

Rural Soc. 25(3):321-333. 1960. (Journal Article 2472 from the Michigan Agricultural Experiment Station)

Based on data from farm boys in a highly urban-industrial region with excellent education facilities, this paper is an attempt to infer a valid explanation for the farm-planner's low levels of educational and occupational aspiration and to explain differential plans regarding farming. The explanation inferred holds that farming is the normal occupational self-conception of farm-reared boys. This normal self-conception may be abandoned if the boy has an unusually self-reliant and inquisitive personality, if his parents are deviants in that they want him to be mobile, or if he perceives farming as inaccessible. If he develops a self-conception of non-farmer he will tend to utilize the information available in the area to develop the higher levels of aspiration needed for successfully entering urban work; if his self-conception remains that of farmer he will tend not to utilize the information. Thus those wishing to increase the levels of occupational achievement of farm-reared youth should attempt to modify the boy's expectation that he will be a farmer by providing more alternatives for him.

Absorption and Mobility of Magnesium^{28} in the Bean *(Phaseolus vulgaris L.)*

BUKOVAC, M. J.; F. G. TEUBNER AND S. H. WITTWER

Amer. Soc. for Hort. Sci. 75:429-434. 1960. (Journal Article 2474 from the Michigan Agricultural Experiment Station)

Foliar-applied magnesium^{28} was readily absorbed (10% in 24 hours) but was not translocated out of the treated leaves of seedling or fruiting bean plants. Magnesium applied to the root medium was absorbed and distributed throughout the plant. In fruiting plants 33 per cent of the root-absorbed Mg^{28} was recovered in the stem and 32 percent in the pods and seeds. The primary leaves accumulated the least (5%) and the trifoliate leaves intermediate (13-16%) amounts. It is suggested that the occurrence of magnesium deficiency symptoms (interveinal chlorosis) in mature leaves results from first, a preferential transport of the currently absorbed magnesium to young tissues, and secondly, from a depression of the magnesium pool available for chlorophyll synthesis, rather than from redistribution or transport to other plant parts.

Regeneration Following Clearcutting of Oak During a Seed Year

GAMMON, A. D.; V. J. RUDOLPH AND J. L. AREND

Jour. of Forestry. 58(9):711-714. 1960 (Journal Article 2476 from the Michigan Agricultural Experiment Station)

Reproduction 7 years after clearcutting an excellent white oak-red oak stand in southern Michigan following a bumper acorn crop is adequate, but composed primarily of white ash, sugar maple, American elm, black cherry, red maple, and very few oaks and yellow-poplar. Most young oak stems are sprout clumps poorly distributed over the area. Oak seedlings have decreased in number in the 7-year period, and have remained unchanged in height for 3 years because of severe

rabbit browsing. In the absence of early cleanings and temporary measures to control the rabbit population, conversion of oak stands to more tolerant species will follow—cutting, even as heavy as clearcutting.

The Effect of Elevated Calcium and Phosphorus Levels on the Zinc Requirement of the Chick

ROBERSON, ROBERT H. AND PHILIP J. SCHAIBLE

Poultry Sci. XXXIX(4):837-840. 1960. (Journal Article 2503 from the Michigan Agricultural Experiment Station)

Three experiments were conducted with chicks to determine the effect of high levels of calcium and phosphorus on the zinc requirement of the chick. Excess calcium depressed growth and feed efficiency and created zinc deficiency. Addition of zinc at 80 parts per million counteracted this effect of the high mineral supplement.

The Availability to the Chick of Zinc as the Sulfate, Oxide or Carbonate

ROBERSON, ROBERT H. AND PHILIP J. SCHAIBLE

Poultry Sci. XXXIX(4):835-837. 1960. (Journal Article 2504 from the Michigan Agricultural Experiment Station)

An experiment was conducted with chicks to determine the availability of zinc in the form of different compounds using semipurified diets. It was found that the sulfate, oxide and carbonate forms of zinc were equally available to the chick at two levels, 10 and 20 parts per million at which it was tested, in the feed. The zinc in these forms produced satisfactory growth of the chick and prevented zinc deficiency symptoms.

Chemical Changes of Jersey and Rubel Blueberry Fruit Associated with Ripening and Deterioration

WOODRUFF, R. E.; D. H. DEWEY AND H. M. SELL

Amer. Soc. for Hort. Sci. 75:387-401. 1960. (Journal Article 2507 from the Michigan Agricultural Experiment Station)

Jersey blueberry fruit of known degrees of ripeness were initially harvested as the skin color became red, and subsequently at 3 or 4-day intervals for 20 days. The following chemical changes of the berries occurred with ripening: total sugars increased for 9 days, then remained constant; titratable acids decreased and pH increased continually; pigmentation increased for 6 days, then levelled off; soluble pectin decreased continually and was associated with increased pectin methyl-esterase activity. Changes in starch, acid hydrolyzable polysaccharides, ether soluble material, lignin and cellulose were nil or slight. Fruit ripening on the bush and fruit deterioration after harvest at 75° F. for 6 days and at 40° F. for 18 days had positive linear correlations to the sugar-acid ratios of Jersey and Rubel fruit at time of harvest.

The Tolerance of Growing Chicks for High Levels of Different Forms of Zinc

Roberson, Robert H. and Philip J. Schaible

Poultry Sci. XXXIX(4):893-896. 1960. (Journal Article 2508 from the Michigan Agricultural Experiment Station)

Three experiments were conducted to determine the tolerance of White Leghorn Chicks to high levels of zinc. Levels of zinc up to 1000 parts per million as the oxide, sulfate and carbonate did not significantly influence the rate of growth of the birds, feed efficiency or livability.

At 1500 p.p.m. of zinc and above, the carbonate and sulfate of zinc adversely affected growth and feed efficiency. Mortality was not severe except at the highest level of 3000 p.p.m. of zinc as the carbonate.

Sex Ratios in Two Strains of Leghorns and Their Reciprocal Crosses Champion, L. R.

Poultry Sci. 39(4):876-881. 1960. (Journal Article 2509 from the Michigan Agricultural Experiment Station)

The secondary sex ratio of 11,931 White Leghorn progeny produced by 23 sires and 442 dams mated in pure strain and reciprocal strain-cross matings were determined by cloacal examinations. Further, sex ratios were determined for (1) progenies from dams with variable fertility records and 100 percent hatchability, and (2) families producing numbers of male or female chicks which differed significantly from equality. Also, primary sex ratio determinations as derived from 255 dams with records of 100 percent fertility and 100 percent hatch were made. The results, by mating type, are presented in seven tables. Two sets of conclusions are given, one set based upon pooled data with large populations involved, and the other set based upon strain and family analyses.

Thyroidal I^{131} Turnover, Thyroxine Secretion Rate and Thyroactive Iodinated Casein Utilization in Mink *(Mustela Vison)*

Reineke, E. P.; Hugh F. Travis and Paul E. Kifer

Amer. Jour. of Vet. Res. 21:862-865. 1960. (Journal Article 2511 from the Michigan Agricultural Experiment Station)

The mean 24-hour thyroidal uptake of I^{131} by 15 10-month-old mink was 8.14 ± 0.315 per cent of the injected dose. Peak uptake of I^{131} by the thyroid was reached in 24 hours. Thyroid output, determined in 5 mink, was at the rate of 19.9 per cent per day (T ½ = 3.48 days). The mean thyroxine secretion rate of 5 male mink, determined by thyroxine substitution, was 0.95γ/100 Gm. per day or 9.92γ daily per kilogram $^{0.75}$. When thyroprotein that contained 1.0 per cent thyroxine was given orally, 0.276 mg./100 Gm. per day provided available thyroxine equivalent to the normal secretion rate. From this comparison, it was computed that 34.3 per cent of the thyroxine in thyroactive iodinated casein protein is absorbed by mink when given orally.

Fatty Acid Distribution in Lipides from Eggs Produced by Hens Fed Cottonseed Oil and Cottonseed Fatty Acid Fractions

EVANS, ROBERT JOHN; SELMA L. BANDEMER AND J. A. DAVIDSON

Poultry Sci. 39(5):1199-1203. 1960. (Journal Article 2517 from the Michigan Agricultural Experiment Station)

Mixed cottonseed oil fatty acids were separated into seven fractions by crystallization from acetone in the cold. Each of these fractions and crude cottonseed oil were fed to groups of laying hens, and the eggs were stored at 0° for almost one year. The substances in cottonseed oil that cause pink-white and salmon-yolk discoloration of stored eggs were concentrated in the fatty acid fraction that was soluble in acetone at –60° C. Egg oil from each group of hens was transmethylated, and the fatty acid composition determined by gas-liquid chromatography. The fatty acid compositions of each cottonseed oil fatty acid fraction and of the basal ration lipides were also determined. Egg lipides contained a higher concentration of stearic acid than did dietary lipides. Supplementing the diet with palmitic, stearic, or oleic acids increased the contents of the respective fatty acids in the egg oil. Linoleic acid supplementation of the basal diet increased the concentrations of linoleic acid and the saturated fatty acids in egg-yolk lipides.

Studies of Bovine Portal Blood I. Establishment and Maintenance of Portal and Mesenteric Vein Catheters

CONNER, G. H. AND G. F. FRIES

Amer. Jour. of Vet. Res. 21(85):1028-1032. 1960. (Journal Article 2519 from the Michigan Agricultural Experiment Station)

A technique for establishing portal vein catheters and for maintaining them in unanesthetized calves is described.

Portal vein catheters were established in 15 dairy calves and were successfully used for the collection of portal blood samples for periods up to 73 days. Calves showed no untoward effects to the catheters and lived an apparently normal life during the period of experimentation.

Evidence is presented to indicate that in one of the 15 calves the portal vein catheter changed position following its initial placement in the porta hepatis.

The Effects of Pre- and Post-Enzyme Inactivation Storage on Irradiated Beef and Pork Roasts

PEARSON, A. M. AND L. J. BRATZLER

Food Res. 25(6):1-6. 1960. (Journal Article 2527 from the Michigan Agricultural Experiment Station)

Raw irradiated beef and pork roasts were heat inactivated after 0, 4, 8, 16, 32 and 64 days storage at 24°C. At the conclusion of each storage period, one pair of roasts was removed for analysis and testing, while an additional pair of roasts was tested after a total storage period of 90 days had elapsed. Results show that raw irradiated beef and pork can be stored at 24°C. for periods

up to 16 days without any adverse effects upon acceptability. Although proteolysis, as measured by the increase in percentage of amino nitrogen, occurred as storage in the raw state was prolonged, the increase was not marked until after 8 days. The increased protein breakdown appeared to contribute to the poor acceptability and mushy texture of roasts held for 32 days storage or longer before enzyme inactivation. The method of heat inactivation seemed to be adequate to prevent further protein degradation, although the texture became poorer with post-enzyme inactivation storage.

(2-Chloroethyl) Trimethylammonium Chloride and Related Compounds as Plant Growth Substances III. Effect on Growth and Flowering of the Tomato

WITTWER, S. H. AND N. E. TOLBERT

Amer. Jour. of Bot. 47(7):560-565. 1960. (Journal Article 2528 from the Michigan Agricultural Experiment Station)

Application of 10^{-3} to 10^{-5} M solutions of (2-chloroethyl) trimethylammonium chloride, (2-bromoethyl) trimethylammonium bromide, or (2, 3-n-propylene) trimethylammonium bromide to the roots of the tomato plant markedly altered growth and promoted earlier flowering. Treated plants developed thicker stems, and dark green savoyed leaves. The growth changes were similar to those produced by exposure to high light intensities and low temperatures, and were opposite to, and more persistent than those induced by gibberellin. A stepwise regulation in the magnitude of growth and dry matter accumulation, without visible injury or a delay in flowering, occurred when the chemicals were added to root media of tomato plants grown in solution cultures, beginning with a significant stimulation in growth at 10^{-7} M, to a marked suppression in growth at 10^{-4} M. The control of growth and flowering by the use of these chemicals offers several practical possibilities for their utilization in tomato culture.

Morphology and Genesis of Some Soils Containing Fragipans in Northern Michigan

YASSOGLOU, N. J. AND E. P. WHITESIDE

Soil Sci. Soc. of Amer. Proc. 24(5):396-407. 1960. (Journal Article 2531 from the Michigan Agricultural Experiment Station)

Detailed physical, chemical, and mineralogical studies were made on profiles representative of the McBride, Isabella, and Nester series. These are bisequal soils that have formed in calcareous sandy loam, sandy clay loam, and clay loam tills, respectively, in Northern Michigan. Each contains fragipan horizons between the overlying illuvial humus iron oxide horizon and the underlying illuvial silicate clay horizon. These horizons interfere with the movement of plant roots and water in the profile. Roots seldom branch in them and tap roots of alfalfa commonly zig-zag through cracks in them.

The alterations of the primary materials necessary for the formation of the fragipans include: leaching of lime, eluviation of the finer expanding lattice clays leaving coarser non-expanding illitic clays, compaction of the layers by the weight of the overlying layers and the tap roots of plants, rearrangement of the finer particles between the sand grains including formation of clay bridges between them.

Supplementation of the Swine Gestation Diet with Pyridoxine

RITCHIE, HARLAN D.; ELWYN R. MILLER; DUANE E. ULLREY AND JACOB A. HOEFER AND RICHARD W. LUECKE

Jour. of Nutrition 70:491-496. 1960. (Journal Article 2536 from the Michigan Agricultural Experiment Station)

Forty-four pregnant swine were lotted into two treatments to study effects of supplemental pyridoxine in a gestation diet. Control lot received a typical gestation ration, and experimental lot received same ration supplemented with 5 mg. of pyridoxine HCL per pound of diet. On two occasions, middle and late pregnancy, sows from both groups were subjected to 48-hour confinement in metabolism cages to determine urinary excretion of several metabolites. At each of these times, complete hematology was performed on each animal. Body weight records were kept on all sows and pigs throughout trial. Hematological determinations were made on all pigs at birth, 1, 3, and 5 weeks of age. Summary and analysis of 10,000 observational items of data were made. The control diet, containing 0.45 mg. of B_6 per pound, appears to be adequate to meet the swine gestation pyridoxine requirement for normal reproduction.

The Effects of Pre-Irradiation Heat Inactivation of Enzymes on Palatability of Beef and Pork

PEARSON, A. M.; L. J. BRATZLER AND R. N. COSTILOW

Food Res. 25(6):681-686. 1960. (Journal Article 2537 from the Michigan Agricultural Experiment Station)

A study was carried out to ascertain the influence of various pre-irradiation enzyme inactivation temperatures upon flavor, texture and amino nitrogen changes occurring during progressively longer periods of storage. Results of panel evaluation, texture observations and percentage of amino nitrogen indicated that the higher external temperatures more effectively destroyed the enzymes in beef. However, for pork the lowest temperature of inactivation appeared to prevent proteolysis and the resulting loss of acceptability. Observations would indicate that prevention of texture changes is a separate problem associated with the storage of irradiated heat treated beef and pork.

The Hormonal Control of Reproductive Activity in the Cycling and Anestrous Ewe

WAGNER, J. F., E. P. REINEKE, J. E. NELLOR AND H. A. HENNEMAN

Jour. An. Sci. 19:607-615. 1960. (Journal Article 2542 from the Michigan Agricultural Experiment Station)

A single injection of progesterone in macrocrystalline suspension inhibited estrus and follicular growth in the cycling ewe for a period of 12 to 16 days. The duration of inhibition depended upon the state of the breeding season when the treatment was administered. In the anestrous ewe, the optimum interval necessary between the injection of progesterone suspension and PMS to induce follicular growth, ovulation, and estrus was 16 days. Approximately 50% of the anestrual ewes treated with progesterone-PMS came into estrus and 37.5% of these lambed following service at the induced estrus. Eighty-seven percent of the anestrous ewes administered 200 μg. of microcrystalline estradiol 30 hours

after the PMS injection exhibited estrus, but only 28.5% of the ewes serviced produced lambs. Although 50 to 200 μg. of the sodium salt of estradiol administered 30 hours after PMS did not influence the incidence of estrus, it definitely enhanced fertility. Five of six ewes serviced following progesterone-PMS-sodium salt of estradiol treatment produced lambs. Ewes that lambed during October were successfully bred 40 to 60 days later while still milking.

Separation and Identification of Cooked Beef Flavor Components

Kramlich, W. E. and A. M. Pearson

Food Res. 25(6):1-8. 1960. (Journal Article 2546 from the Michigan Agricultural Experiment Station)

Collection of the different components in the volatile fraction of cooked beef was accomplished by freezing out in a trap immersed in liquid air. The components were then separated and identified by means of gas or paper chromatograms coupled with various qualitative tests. Carbon dioxide, methyl mercaptan, acetone and acetaldehyde were found to be present, while methyl sulfide and water were tentatively identified. Although a somewhat beef-like flavor was produced on bubbling the mixed volatiles through distilled water, the relative importance of the various contributing components remains to be resolved

Cystine Content of Proteins, Foods, and Feeds. Comparison of Chromatography on a Sulfonated Polystyrene Resin and Microbiological Methods of Determination

Evans, Robert John; Selma L. Bandemer and Doris H. Bauer

Agr. and Food Chem. 8(5):383-386. 1960. (Journal Article 2548 from the Michigan Agricultural Experiment Station)

The cystine content of a number of proteins, foods, and feeds was determined by four different procedures: chromatography of cysteic acid and microbiological assay using a lanthionized casein medium after 30 minutes of hydrolysis and using an oxidized peptone medium after either 30 minutes or six hours of hydrolysis by autoclaving. Chromatography and the two microbiological assay procedures using a 30 minute hydrolysis period agreed well for the most part. Most of the cystine values obtained by microbiological assay of the six-hour digests were lower. One commercially isolated soybean protein preparation contained more cystine by the chromatographic procedure than by microbiological assay indicating a loss of cystine availability during the preparation of the protein.

A Progress Report on Horticultural Problems Associated with a Mechanical Tomato Harvester

Ries, S. K. and B. A. Stout

Amer. Soc. for Hort. Sci. 75:632-637. 1960. (Journal Article 2553 from the Michigan Agricultural Experiment Station)

The farm value of tomatoes for processing purposes in the United States exceeds $120 million annually. Approximately 40 per cent of the tomato crop is used to pay harvesting expenses.

The Michigan State University tomato harvester operates on a once-over principle. The vines are cut below the ground surface, and elevated onto a shaker bed where all the fruit is removed.

Tests have been conducted on 12 tomato varieties. The best varieties for harvest have determinate type vine growth with concentrated fruit set.

Yields up to 18 tons per acre of ripe, acceptable fruit have been harvested mechanically. Higher yields have been obtained by a single hand harvest followed by machine harvest.

Damage to the fruit has been highly variable and has ranged from no breakage up to as much as 10 per cent broken fruit.

Mechanical harvesting of tomatoes now appears feasible. Many refinements will be needed to improve the performance of the machine.

Differences in Food Buying Attitudes of Housewives

TRIER, HOWARD, HENRY CLAY SMITH, AND JAMES SHAFFER

Jour. of Marketing 25(1):66-69. 1960. (Journal Article 2554 from the Michigan Agricultural Experiment Station)

An exploratory study of decision making in food buying which is concerned with the following questions: How do wives differ in their approach to food buying? Is the approach to food buying related to their perceived roles and their perceptions of self? Is there a relationship between the personality traits of the wives and their approach to food buying?

Quackgrass Control in Potato Production

ISLEIB, D. R.

Weeds 8(4):631-635. 1960. (Journal Article 2558 from the Michigan Agricultural Experiment Station)

Quackgrass was controlled effectively by application of dalapon to growing leaves in early spring followed in seven to ten days by field cultivating, plowing and planting. Yields of potato tubers were increased where quackgrass was controlled chemically compared with areas which received cultivation alone.

Supplemental nitrogen applied in early spring did not increase quackgrass control. The extra nitrogen had an expected stimulatory effect on potato growth but did not result in significant yield increase.

Mechanical cultivation, both before planting and after crop emergence, increased the control obtained with herbicide treatments. Under the severe conditions of quackgrass infestation of these experiments, four field cultivations before plowing were better than a single field cultivation (1958), and four row cultivations were better than a single row cultivation (1955).

Measurement of the Cross-Sectional Area of the Loin Eye Muscle in Live Swine by Ultrasonic Reflections

PRICE, J. F., A. M. PEARSON AND J. A. EMERSON

Jour. of An. Sci. 19(3):786-789. 1960. (Journal Article 2563 from the Michigan Agricultural Experiment Station)

Estimates of the cross sectional picture of the loin in 41 live hogs were made utilizing ultrasonic reflection measurements coupled with angles of incidence at

a scheduled series of sites over the last rib. Although some subjective judgment was necessarily involved in completing the ultrasonic plots, the mean of these estimates of muscle size was not significantly different from the area of the loin eye muscle measured from tracings of the rough loin. The relationship between the ultrasonically plotted area and the actual area obtained from tracing the muscles was .74. Although the ultrasonic method of determining muscle size in live swine was too time consuming and tedious to be useful in marketing hogs, the method appears to offer promise for selecting breeding stock with large eye muscle areas.

Pea Introductions with Partial Resistance to Aphanomyces Root Rot

Lockwood, John L.

Phytopathology 50(8):621-624. 1960. (Journal Article 2567 from the Michigan Agricultural Experiment Station)

Several pea introductions gave consistently lower disease indices than commercial varieties in replicated tests in the greenhouse sand. Those with lowest disease indices were P.I. numbers 166159, 167250, a selection of 169604, 180693, 180702, 180868, and 184129. Those with highest levels of resistance had disease indices of approximately 3.0 as compared with disease indices of approximately 8.0 (the maximum disease index, indicating dead plants) for commercial varieties. Graphical data and statistical analysis indicated that a significant relation existed between disease indices for P.I. 169604 selection and Miragreen, and for P.I. 180693 and Miragreen. Several accessions consistently gave resistant reactions when tested under variable conditions in the greenhouse. Variable factors were a) zoospore concentration, b) age at which plants were inoculated, c) temperature of sand, d) isolate of *Aphanomyces euteiches*, e) age of culture. P.I. 180693 and P.I. 169604 selection were less severely diseased than Miragreen when grown in the greenhouse in steamed soil inoculated with the pathogen. In field experiments in 1958 and 1959 P.I. 169604 selection showed little or no resistance to root rot when compared with Early Perfection. One of the 4 isolates of *A. euteiches*, isolate 102, appeared to be pathogenically distinct from 3 other isolates.

Eugenics in Crops

Grafius, J. E. and M. W. Adams

Agron. Jour. 52:519-523. 1960. (Journal Article 2571 from the Michigan Agricultural Experiment Station)

A vector model has been developed whereby it appears possible to predict the best parents and combination of parents to produce progenies which have means approaching an ideal for a large number of traits. This in effect is an attempt to make the progeny mean coincide with an ideal for a large number of traits.

The model which has been presented for examination is based on 13 traits for 18 barley varieties, but it will apply to both self-fertilized and cross-fertilized species.

Simazine for Controlling Weeds in Fruit Tree and Grape Platings

LARSEN, R. P. AND S. K. RIES

Weeds 8(4):671-677. 1960. (Journal Article 2573 from the Michigan Agricultural Experiment Station)

Simazine (2 to 16 pounds per acre) was applied around various ages and varieties of apple, sour cherry, peach and pear trees during 1958 and 1959. Growth of young apple and peach trees treated with simazine was greater than in untreated checks. Commercially acceptable control of weeds was obtained under bearing and non-bearing trees with 8 or 16 pounds per acre; weeds were not adequately controlled at rates lower than 8 pounds per acre. Foliage injury of cherries and peaches resulted from the 16 pound per acre rate.

Simazine (2 to 8 pounds per acre) was applied under 4-year old Concord grape vines at East Lansing and Sodus, Michigan. Acceptable weed control was obtained with 8 pounds per acre of simazine loam soil at East Lansing. All treatments provided acceptable weed control on sandy loam soil at Sodus. There was no evidence of injury to the vines from any treatment. Fruit yields of the herbicide treatments, at Sodus, were significantly higher than untreated checks.

Manometric Calibration for Insect Respiration

HOOPINGARNER, ROGER AND STANLEY D. BECK

Annals of the Entomological Soc. of Amer. 53(5):697-698. 1960. (Journal Article 2578 from the Michigan Agricultural Experiment Station)

Normal manometric technique using Mercury for volume measurement is not possible for whole insects on diets. An air calibration technique was modified to allow whole insects, on treatment diets, to be considered when volume measurements were taken.

An Evaluation of the Rate of Reproduction of the Two-Spotted Spider Mite Reared on Gibberellin-Treated Bean Plants

EICHMEIER, JACK AND GORDON GUYER

Jour. of Econ. Enty. 35(4):661-664. 1960. (Journal Article 2585 from the Michigan Agricultural Experiment Station)

An investigation was established to determine if populations of two-spotted spider mites, *Tetranychus telarius* (L.), were affected when reared on Tendergreen variety of snap beans treated with gibberellin. Five treatments of gibberellin were evaluated. Four mite-disc arrangements were included in each treatment. There were significant reductions in mite populations on plants treated with certain gibberellin applications. There appeared to be differences resulting from factors other than direct plant growth. The rate of reproduction of mites was low on treated plants, but rose rapidly and became almost normal when these mites were returned to untreated plants. Mites raised on untreated plants and transferred to treated plants showed a drop in reproduction within one generation.

Results of Crossing *Brassica pekinensis* (Lour.) Rupr. with *B. oleraceae* L. var. *acephala* Dc.

HONMA, SHIGEMI AND OTTO HEECKT

Euphytica 9(2):243-246. 1960. (Journal Article 2588 from the Michigan Agricultural Experiment Station)

Success in obtaining an interspecific hybrid between *B. pekinensis* and *B. oleraceae* var. *acephala* was possible through the use of the Chinese cabbage as the seed parent and the use of the growth regulator, N-m-tolylphthalamic acid. The hybrids appeared vegetatively intermediate between the parents except for the inflorescence which appeared more like the kale parent. The F_1 was back-crossed with ease to the Chinese cabbage parent using the hybrid either as the pollen or seed parent. No back-cross was made to the kale parent. Segregation in the F_2 was continuous for most characters studied.

Steroidal Esters of 3-Indoleacetic Acid[1-3]

HOFERT, JOHN F. AND HAROLD M. SELL

Jour. of Organic Chem. 25:1831-1832. 1960. (Journal Article 2594 from the Michigan Agricultural Experiment Station)

Cholesteryl 3-indoleacetate, ergosteryl 3-indoleacetate, 7-dehydrocholesteryl 3-indoleacetate, cholestanyl 3-indoleacetate and β-sitosteryl 3-indoleacetate were synthesized by reacting the appropriate sterol with 3-indoleacetyl chloride. The steroidol esters had very little biological activity as determined by the tomato ovary test.

Effect of a Modified Sulfite Waste Liquor and of Calcium Gluconate on Milk Production

EMERY, R. S.; C. K. SMITH; T. R. LEWIS; JUNE DEHATE AND L. D. BROWN

Jour. of Dairy Sci. 43(11):1643-1647. 1960. (Journal Article 2605 from the Michigan Agricultural Experiment Station)

Milk production was increased by 0.6 to 1.9 lb. per head per day when dairy cows were supplementally fed 0.25 lbs. per day of a modified dried sulfite waste liquor from paper pulp manfacturing. This 4 month field trial included 171 control and 143 treated cows from 12 herds each of which was divided between the two groups. Gluconic acid, a constituent of the modified sulfite waste liquor, was attacked very slowly by rumen microorganisms and is not a common constituent of dairy cattle feeds. When 2 groups of 5 cows each were fed 0.125 lb. per day of calcium gluconate in a reversal design with two 28 day periods, the treatment increased fat corrected milk by 1.5 lb. per cow per day ($P<0.01$). The calcium gluconate feeding resulted in a slightly higher weight gains.

2-Chloroethyl Trimethylammonium Chloride and Related Compounds as Plant Growth Substances. V. Growth, Flowering and Fruiting Responses as Related to Those Induced by Auxin and Gibberellin

WITTWER, S. H. AND N. E. TOLBERT

Plant Physiology 35(6):871-877. 1960. (Journal Article 2610 from the Michigan Agricultural Experiment Station)

Vegetative and reproductive response induced in plants or plant parts by 2-chloroethyl trimethylammonium chloride or related compounds, gibberellin, and 3-indoleacetic acid indicated that closely related yet distinct systems were involved. 2-Chloroethyl trimethylammonium chloride suppressed the gibberellin and light induced germination of lettuce seed, vegetative extension of genetically dwarf and normal plants, elongation of plants in light and dark, and flowering of lettuce, a facultative long day plant. With Biloxy soybeans flowering was not affected, but the chemical induced vegetative growth under long days, which was equivalent to a short-day photoperiodic inhibition. Elongation of Avena coleoptile sections was suppressed both in the presence and absence of 3-indoleacetic acid. The suppression of the 3-indoleacetic acid response was partially overcome by gibberellin. There was no direct effect of 2-chloroethyl trimethylammonium chloride on the growth of tomato ovaries. However, in combination with 10^{-3} M 3-indoleacetic acid and 10^{-5} M gibberellin a synergistic growth rate was induced beyond that which could be ascribed to a 3-indoleacetic acid-gibberellin interaction.

L-Xylulokinase and L-xylulose 5-phosphate-L-ribulose 5-phosphate 3-epimerase in *Aerobacter aerogenes*

ANDERSON, R. L. AND W. A. WOOD

Biochem. Biophys. Acta. 42:374-376. 1960. (Journal Article 2611 from the Michigan Agricultural Experiment Station)

A new metabolic sequence has been established for L-xylose metabolism in *Aerobacter aerogenes*. During growth on L-xylose, four new enzymes are induced for its metabolism, L-xylose isomerase, L-xylulokinase, L-xylulose 5-phosphate 3-epimerase, and L-ribulose 5-phosphate 4-epimerase. These catalyse the following reactions, respectively, L-xylose → L-xylulose → L-xylulose-5-phosphate → L-ribulose-5-phosphate → D-xylulose-5-phosphate. By this means the L-sugar reaches the main metabolic pathway in sugar utilization. Chemical evidence for the enzymes and the intermediates was reported.

***In Vitro* Uptake of I^{131} by Mammary Tissue**

MAQSOOD, M. AND E. P. REINEKE

Amer. Jour. of Physiology 199(5):829-832. 1960. (Journal Article 2614 from the Michigan Agricultural Experiment Station)

In vitro uptake of I^{131} by lactating rat mammary tissue, incubated at 37°C for 6 hours, was 10-15 times that of liver, muscle or boiled mammary tissue. Uptake was greatly reduced by thiouracil and blocked by KSCN, NaCN or incubation under N_2. It was increased to about twice the level observed in fresh

mammary tissue after storage overnight at 7°C., but decreased rapidly during storage (with penicillin) at 37°C. I^{131} uptake by fresh mammary tissue was low during early pregnancy and increased sharply from 15 to 20 days of gestation. It increased further during lactation and decreased to minimal values after 10 days of mammary involution. Significant I^{131} uptake also occurred in lactating mammary tissue of mouse, guinea pig, rabbit and cow. Incubation of lactating rat mammary tissue with varying concentrations of prolactin TSH, growth hormone, insulin or hydrocortisone had no effect on its I^{131} uptake. The data indicate that a simple enzyme system, not closely associated with respiratory metabolism, is involved in iodide collection by lactating mammary tissue. Though quite stable at 7°C., it is inactivated by boiling or by storage at 37°C.

Thermal Resistance of Microorganisms to Dry Heat: Design of Apparatus Operational Problems and Preliminary Results

PFLUG, I. J.

Food Technology 14(10):483-487. 1960. (Journal Article 2624 from the Michigan Agricultural Experiment Station)

An apparatus was designed and constructed for determining the resistance of bacterial spores to dry heat conditions at temperatures in the range 149 to 193° C. Four replicate samples are tested at a time; the samples are moved into and out of the apparatus by a pneumatic mechanical action. Electric strip heaters are used to maintain the temperature of the machine while the gas that is used as the testing medium is heated in an electric gas heater. Temperature control is affected by varying gas flow through the system while the energy input is held constant. The heating and cooling lag correction factors were evaluated and range from 0.12 to 0.31 min. depending on the gas used, the flow rate and the z of the thermal destruction rate curve. The heat resistance of a strain of B subtilus in superheated steam was determined and found to have a D_{350} of 0.57 min. and a z of 42° F. The same suspension of the organism had a wet heat resistance D_{250} of 0.35 min. and a z of 14.8° F.

The Bionomics of a Coleophorid Associated with Asparagus Spears

GUYER, GORDON; RAY HUTSON AND ARTHUR WELLS

Canadian Entomologist 92(10):721-723. 1960. (Journal Article 2631 from the Michigan Agricultural Experiment Station)

The first lots of asparagus received at processing terminals in the Shelby, Michigan, area in May of 1959 were contaminated with case-bearer larvae of the family Coleophoridae. Minor feeding scars were observed on some spears. The principal problem resulted when the larvae crawled under the bracts and into the heads of the spears. From adult specimens collected in August the insect was identified as *Coleophora amaranthella* BRAUN.

In October seed heads of the rough pigweed, *Amaranthus retroflexus* L., were observed to be heavily infested with case-bearer larvae. The larvae overwintered in plant debris in asparagus fields. A weed control program was initiated to remove the *Amaranthus* plants from Michigan asparagus fields and thus eliminate the necessity for chemical control.

Effect of Mineral Supplementation on Pork Muscle Color as Measured by Spectrophotometry and Disk Colorimetry

HENRY, W. E. AND L. J. BRATZLER

Jour. of Animal Sci. 19(4):1195-1203. 1960. (Journal Article 2633 from the Michigan Agricultural Experiment Station)

Two trials were conducted using 36 purebred Hampshire and 44 crossbred hogs to determine the effects of breed, and the effect of zinc, iron, and copper supplementation upon color and myoglobin content of pork muscle using sections of the *Longissimus dorsi*. Surface color measurements were made by use of Munsell spinning disks. Myoglobin values were determined spectrophotometrically.

Statistical analysis indicated non-significant relationships between mineral supplementation and myoglobin concentration. In addition, non-significant relationships were found between breed and myoglobin concentration.

A highly significant relationship ($R = -0.69$) was found between index of fading and myoglobin concentration. Non-significant correlation coefficients were obtained upon comparing index of fading with ether extract (0.21) and total moisture (–0.16). Correlation coefficients between myoglobin concentration and ether extract and total moisture were non-significant (–0.29 and –0.13, respectively).

Development of a Mechanical Tomato Harvester

STOUT, B. A. AND S. K. RIES

Agr. Eng. 41(10):682-685. 1960. (Journal Article 2649 from the Michigan Agricultural Experiment Station)

A mechanical tomato harvester was developed based on a "once-over" harvest principle. The plants are cut off just below the soil surface and elevated to a shaker bed which reciprocates with a 4 inch stroke at 175 to 200 cycles per minute. All the fruit are shaken from the plant onto an inclined rubber belt. The fruit roll down the slope into a conveyor while the dirt and foreign material is carried up the slope and discarded. The fruit are stored in any suitable container.

This principle of harvest requires a variety which has concentrated fruit set (i.e. a high ratio of ripe to green fruit at harvest time) in addition to the usual requirements of processing tomato varieties. Several promising varieties are being developed by the plant breeders.

Mechanical harvester tests were conducted on ten varieties at the Michigan State University horticultural farm and two varieties in commercial fields. Mechanically harvested yields from the more promising varieties in the Michigan State University plots ranged from 2.0 to 9.9 tons of ripe fruit per acre, while yields up to 18 tons per acre were obtained in one mechanically harvested commercial field.

Design Analysis for Poultry House Ventilation

ESMAY, MERLE L.

Ag. Eng. 41(9):576-578. 1960. (Journal Article 2669 from the Michigan Agricultural Experiment Station)

In proposed new poultry houses or existing old ones, two questions arise:

1. How much ventilation air exchange is possible?
2. How much water will the air remove?

If no supplement heat is added to the house, the amount of air exchange possible is based upon the difference between the heat loss from the house by conduction and heat produced by the birds.

The graphical analysis presented in this paper shows the relationships of size and shape, insulation, inside and outside temperatures, and bird density to the possible air, heat and moisture removal from the house.

Thermostatically controlled exhaust ventilation fans should provide for a minimum of 3 cu. ft. of air exchange per minute per sq. ft. of floor area for poultry laying houses in the northern zones of the United States. For more nearly continuous winter time ventilation fans to provide from one-half to one cfm of air exchange per sq. ft. of floor area may be connected to one thermostat which would be set at the minimum desirable temperature in the house. The remainder of the fans would be connected to a second thermostat set at from 3 to 5 degrees above.

Arthrocentesis of the Equine Carpus

VAN PELT, R. W.

Vet. Med. 55(12):30-34. 1960. (Journal Article 2678 from the Michigan Agricultural Experiment Station)

The value of arthrocentesis and injection of intra-articular adrenocortical steroids was discussed in the light of anti-inflammatory action at the joint level.

Contrast arthrograms employing a 50% solution of diatrizoate sodium have been used to demonstrate the confines and ramifications of the carpal articulations. This serves as a means whereby one can visualize the structures that come in contact with intra-articular adrenocortical steroids.

A technic for arthrocentesis and injection of the radio-carpal and inter-carpal articulations has been described. Since the carpo-metacarpal articulation communicates with the intercarpal articulation arthrocentesis and injection of this joint was not discussed.

The Quarterly Bulletin

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents progress reports on long-term major research projects and final reports on short-term projects.